AIRSTRIP PAVING MATERIALS

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OF MICHIGAN

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BEFORE THE

SUBCOMMITTEE FOR SPECIAL INVESTIGATIONS

OF THE

COMMITTEE ON ARMED SERVICES
HOUSE OF REPRESENTATIVES

EIGHTY-FIFTH CONGRESS

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AIRSTRIP PAVING MATERIALS

THURSDAY, JANUARY 9, 1958

HOUSE OF REPRESENTATIVES,
COMMITTEE ON ARMED SERVICES,
SUBCOMMITTEE FOR SPECIAL INVESTIGATIONS,
Washington, D. C.

The subcommittee met at 10 a. m., Hon. F. Edward Hébert, chairman of the subcommittee, presiding, with the following members present: Mr. Hess, Mr. Gavin, Mr. Cunningham, Mr. Fisher, Mr. Hardy, and Mr. Osmers.

Mr. HÉBERT. The committee will be in order.

Mr. COURTNEY. Mr. Chairman, the purpose of this meeting is to hear from the Corps of Engineers on a test which is being conducted, or to be conducted at Columbus Air Force Base, Miss., on criteria to be established for airstrip having materials.

The last action of the subcommittee was on July 3, 1957, when a test was proposed and agreed to.

The subcommitee issued an interim report on August 14, 1957, which is a part of the formal proceedings and the public record of the subcommittee.

Now, in the interval, Mr. Chairman, the Corps of Engineers and the Department of Air Force representatives have conducted several hearings and meetings looking to the test, the last of which was in October 1957, and in accordance with the plans announced at the last hearing of the subcommittee all of the interested organizations and individuals who desired to participate in the discussions looking to the final form of the test were accorded an opportunity to and as many as desired did present themselves and participate in those discussions.

I have here, Mr. Chairman, a list of the organizations attending what is described as the Atlantic Design Conference. That is the one held in October 1957, to which I have just made reference.

I should like to have that list incorporated for the record, Mr. Chairman.

Mr. HÉBERT. Without objection.

(The list is as follows:)

LIST OF ORGANIZATIONS ATTENDING ATLANTIC DESIGN CONFERENCE

Chief of Engineers
South Atlantic Division, Corps of Engineers
Mobile District, Corps of Engineers
Headquarters, United States Air Force
Air Force Installations Representative, United States Air Force
Installation Engineer, Columbus Air Force Base representing SAC
Bureau of Yards and Docks, United States Navy
Bureau of Public Roads
Civil Aeronautics Administration

Portland Cement Association
Asphalt Institute
National Bituminous Concrete Association
Associated General Contractors
Shell Oil Co.

Mr. COURTNEY. Mr. Chairman, in addition to that, several of these organizations have corresponded with the Corps of Engineers and the Corps of Engineers has kindly furnished the committee with copies of their material and their suggestions and will in the course of this presentation this morning explain, the Corps, that is, its disposition of the requests and suggestions.

In addition to that, Mr. Chairman, I have received this morning a letter dated January 8, 1958, from the National Bituminous Concrete Association, one of the participants, relating to a program being conducted in Australia and pertinent, it is felt in their opinion, to this discussion.

I shall with your permission, Mr. Chairman, hand this to the Corps of Engineers for such comment as they may deem appropriate and ask that it be incorporated as a part of this record.

Mr. HÉBERT. Without objection.

(The document is as follows:)

MR. JOHN J. COURTNEY,
Special Counsel, Subcommittee for Special Investigations, Committee on Armed Services, House of Representatives, Old House Office Building, Washington, D. C.

DEAR MR. COURTNEY: I am attaching a tear sheet from a recent issue of the Engineering News-Record which is self-explanatory. Certainly the Australians are not any smarter than we are in this country, although it seems they can build asphalt airfields to accommodate their heaviest aircraft and also our own B–52's.

I am also enclosing another document which was presented at the International Air Transport Association Conference in Florida recently. It indicates that the Department of Defense is still obstinate in their opinions.

These are being submitted with the feeling that they may be of interest to you, and you may want to retain them in your files.

Yours very truly,

H. K. GRIFFITH, *Executive Director.*

AUSTRALIAN AIRPORT GETS ADDED RUNWAY

An 11,000-foot runway with 1,000-foot overruns at each end—capable of carrying the world's heaviest aircraft—is nearing completion at Darwin, Australia. Work is being done by a Royal Australian Air Force construction force of about 400 men at an estimated cost of $10.1 million.

The runway and accompanying taxi strips are designed to carry heavy aircraft, similar to the 200-ton United States Air Force B–52. It is planned to open the new runway to air traffic by March or April of 1958. Pavement will be asphaltic concrete, over a soil-cement stabilized base.

All aircraft from the United Kingdom by way of the Middle East, and from Southeast Asia enter Australia through Darwin. Strategic bombers operated by the United States Air Force also will be able to land there, and the new installation thus becomes an important factor in Australian defense plans.

International Air Transport Association, Tenth Technical Conference, Miami, November 1957—Agenda Item 4: Apron Requirements for Turbine Powered Aircraft

(Presented by U. S. Department of Defense)

INTRODUCTION

1. Apron requirements in the Air Force for turbine-powered aircraft are based, without exception, on those imposed by the operational characteristics of jet-engined strategic and tactical military aircraft. This paper, therefore, does not treat of the behavior of these aircraft with any specific reference to the handling of passenger, baggage, and freight operations, and accordingly, the conclusions reached may be applicable in that respect only in general terms.

2. Since the advent of the jet-engined aircraft, the apron parking area requirements for the Air Force have constantly increased. This increase is due not only to the increased size of the aircraft but also to the safety clearances imposed by the blast and heat effects created by the aircraft engines which also have been improved in their thrust output. Likewise, the selection of the type of pavement to offset the effects of heat and blast and to meet other critical factors, such as heavy wheel loads, high tire pressures and channelized traffic, presented considerable challenge to the Department of the Air Force. Naturally, the Air Force is deeply concerned about these increased apron parking requirements because airfield pavements have, and still do, represent a sizable portion of the annual military construction programs presented to the Congress of authorization and funding.

TYPES OF PAVEMENTS

3. No other airfield construction item has been so controversial and has received more widespread attention than that involving the type of airfield pavement which is best suited for jet-engined aircraft. Initially, before 1950, there were indications that the effects of jet fuel spillage and the heat and blast from engine exhausts might be troublesome; however, these did not appear insurmountable.

Funds were limited at that time, and designs for high quality asphaltic concrete pavement had been developed that were relatively inexpensive and appeared to give promise of satisfactory performance. Consequently, the early decision of the Air Force (1951) was based on the premise that selection of the pavement type would be predicated on lowest first cost. Later experience, however, with heavier wheel loads and with repeated fuel spillage, the latter resulting in deterioration and subsequent erosion of the pavement by the hot jet blasts, indicated that asphalt pavements were seriously vulnerable. By 1954, despite the development of a bituminous pavement more highly resistant to jet fuel, it was recognized that the performance of asphaltic pavements was unsatisfactory and a requirement for portland cement concrete in critical areas, which included parking aprons, was advanced.

Since that time, despite additional tests and experience with asphaltic pavements, including the development of a tar-rubber concrete, there have been clear indications that it is impossible to construct a flexible pavement of uniform quality throughout its multilayered system, and because aircraft continued to increase in size and weight, the previous determination that all primary-use pavements would be constructed of portland cement concrete was substantially reconfirmed.

These Air Force criteria which also impose a requirement for secondary or blast-proof paving around the perimeters of aprons and in other areas susceptible to blast erosion remain in force today.

4. Operators of commercial airports will be confronted with the same problems covering airfield pavements. It is evident that the maximum weight of jet-powered aircraft is not in sight, and unless the aircraft designer includes multiple-wheel assemblies to support these heavier aircraft, commercial airports may not be able to accommodate them without incurring damage to their pavements.

AIRCRAFT PARKING PLANS

5. The concern felt by the Air Force in the aircraft parking apron requirements is also reflected, in no small way, in the continuous parking studies conducted by the Department having for their prime purpose the development of more efficient parking schemes and possible reduction of the areas required and

cost therefor. Stub parking, that is the parking of individual aircraft on dead-end pavements which connect to a common taxiway, has been resorted to as a means of eliminating underwing paving and providing only that prime pavement required to support gear loads and permit safe and efficient aircraft movements. Initially, this method of parking, particularly for aircraft having wing spans as much as 230 feet, appeared to be the logical solution; however, the matter of providing paving under overhanging engines to eliminate erosion resulting from engine blasting and for supporting motorized as well as fixed equipment to service these aircraft, reduced the benefits under this scheme considerably. While stub parking is still in use by the Air Force and is considered highly desirable in many respects, it does have other limitations in that aircraft must be generally tugged into parking position and being normally constructed and tailormade for specific aircraft, it does not lend itself to efficient adaptability to aircraft of other sizes and configurations.

6. The major portion of aircraft parking in the Air Force is accommodated on rectangular paved areas or mass-parking aprons. The latest scheme for large jet-powered aircraft envisages a mass-parking apron of long and narrow configuration with blast deflector fences constructed parallel to the longitudinal axis of the apron and located some distance off each side of the pavement. The aircraft will be parked in the two rows with their tails toward the fences and with a longitudinal taxiing lane between the noses of the aircraft. This plan takes into account the turning characteristics of the aircraft and permits engine operations and aircraft movements without damaging adjacent parked aircraft or injury to personnel. Recent studies also indicate advantages could be gained, particularly on existing aprons, by parking the aircraft in double rows, transversely and tail to tail with blast fences in between to make the maximum utilization of existing mass apron. In this instance, a taxiing lane would be provided between the noses of each two rows of parked aircraft which would then connect with the taxiing lanes on each longitudinal side of the apron.

APRON SERVICES AND UTILITIES

7. Major problems which the Air Force has had to face, and frankly have not yet been fully solved to the desired degree in connection with the parking of jet-engined as compared to the propeller-driven aircraft, include the fueling of the aircrfat and the provision of fixed or portable facilities to satisfy the special servicing requirements. It is quite obvious that the enormous increase in aircraft size and weight of the military jet-engined aircraft, the latter result in primarily from greater capacity fuel loading to satisfy higher engine thrust output and extension of cruising range, dictated radical changes in previous ground fuel servicing as well as fuel storage operations. When one considers the number of aircraft involved and the fact that the fuel loading of the large aircraft well exceeds the capacity of one or more railroad tank cars, it is evident that the rapid refueling requirements imposed by the mission of the Air Force could not be satisfied by merely raising the base fuel-storage capacity and by increasing the number of fuel servicing tank trucks to load to the aircraft. This matter was further complicated by the realization that it was not economical to provide and/or specifically designate extensive apron areas for aircraft-fueling operations or even feasible to move the aircraft to such areas once they have been positioned in their normal parking spaces.

8. For the reason the Air Force has for a number of years adopted the concept of providing intermediate underground storage and hydrant dispensing systems, complete with pumps, water separators, meters, and electrical controls including defueling capability immediately adjacent to and for servicing small groups of, parked aircraft, whether these aircraft be located on stubs or mass aprons. These intermediate storage systems are fed by distribution mains from the base bulk storage supply area. Newly constructed or rehabilitated existing parking areas contain built-in outlet grids under the pavement which are connected to and extend from the intermediate storage and dispensing systems. Where stub parking is utilized, a fueling outlet is usually provided for on each stub. Earlier scheme to position a number of hydrant outlets along the taxiway connecting the parking stubs was abandoned because of anticipated interference with aircraft movements during normal and emergency war plan operations. Naturally, on mass aprons where a grid arrangement of outlets has been provided, it may be necessary to adapt the aircraft

parking plan to the extent required to accomplish fueling operations. This is particularly true where a grid system designed for, say, heavy bombardment type aircraft is to be utilized by medium or light bombers.

9. As in the case of fueling, the requirement for electrical energy to service the aircraft in their parked positions as well as for engine starts has been recognized by the Air Force. However, a similar grid arangement of weather-protected electric power outlets in parking aprons and in low-mounted positions adjacent and in close proximity to parking pavements has not proved satisfactory and, except in specific cases where shelters are to be provided, is not in general use now or planned in the foreseeable future. Electrical energy requirements on aircraft parking aprons are currently being met through the use of portable and truck-mounted equipment. A comparatively recent innovation resulting from a requirement to protect the parked aircraft from the weather elements and also to permit the performance of minor maintenance has been the erection of wing hangars on and immediately abutting mass aprons and on parking stubs. (See figure.) Where such hangars are provided, necessary utility services are included in the hangar erection package.

10. A necessary adjunct to aircraft parking pavements is the provisions of tie-down rings or mooring anchors to secure aircraft which are susceptible to serious damage during heavy windstorms. The Air Force has standardized on a grid with the mooring points installed on 30-foot centers in rows 30 feet apart with staggered spacing in alternate rows. These tiedowns also serve for grounding of static electricity during fueling operations and, to assure the proper conductivity, normally consist of 6-foot copper-weld rods driven into the subgrade underlying the aircraft pavements.

11. To assure that all possible precautions are taken to reduce risk from fires originating on and adjacent to aircraft parking aprons, special criteria have been established by the Air Force for the location of fire-reporting stations and fire hydrants. These criteria provide for stations to be located within 500 feet of parked aircraft and wing hangars which may be sited on or abutting aircraft parking aprons. Fire reporting telephone stations are required within 300 feet of aircraft fueling systems, such as the intermediate storage facilities previously mentioned. Fire hydrants are spaced so that all aircraft parking locations, wing hangars, and intermediate fueling facilities within 300 feet. The 300-foot hydrant spacing specification is waived, however, where the apron configuration would necessitate the installation of fire hydrants within the apron proper. In such instances, hydrants are specified on a 300-foot peripheral spacing to serve parked aircraft not to exceed 600 feet distant.

12. In connection with the parking of aircraft, indeed with all aircraft operations on an airfield, a serious problem which has not yet been solved involves the damage to jet engines by foreign objects entering the air intakes. Wind, rain, vehicles, including the aircraft and personnel on foot are responsible for carrying debris onto airfield pavements. Additionally, such items as bolts, nuts, wire, tools, and other metallic objects may be found on pavements and become potential hazards to jet engines. Pavements have to be constantly inspected and swept, and at times flushed clean.

The rotary-type broom sweeper in common use today is not considered to be effective. A positive action vacuum type sweeper has been developed and is now in pilot production; however, because of its size, its use will be limited to large open areas. A need still exists for a small pickup sweeper which can be maneuvered close to parked aircraft.

13. The determination as to which aircraft parking configuration or even a multiple scheme to utilize is based on a number of considerations in addition to the cost factor. The large parking areas required at any one airfield and the limited space provided by the existing or planned runway layouts, not to mention excessive taxiing distances, noise problems with relation to administrative and personnel facilities and even terrain difficulties, often dictate extreme variations in or combinations of aircraft-parking schemes. The Air Force in recognition of these and other associated planning problems relies on a master plan for each of its airbases, thus translating the assigned mission into planning factors capable of being implemented as the needs arise with a high degree of practicability through subsequent construction and rehabilitation. Whatever the procedures may be for planning and providing aircraft parking pavements in the future, the sheer magnitude of the requirements imposed by current and projected types of turbine-powered aircraft will demand the combined efforts of the plan-

ners, engineers, and the responsible municipal authorities to assure the maximum benefits for the dollars expended.

(The comments requested of the Corps of Engineers on the foregoing follows:)

DEPARTMENT OF THE ARMY,
OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., January 22, 1958.

Hon. F. EDWARD HÉBERT,
Chairman, Subcommittee on Special Investigations, Committee on Armed Services, House of Representatives.

DEAR MR. CHAIRMAN: In response to your request that the Chief of Engineers review the material contained in a letter to the subcommittee from the National Bituminous Concrete Association, dated January 8, 1958, I am returning the copy of the letter together with our comments.

Sincerely yours,

E. A. BROWN, Jr.,
Brigadier General, USA,
Assistant Chief of Engineers for Military Construction.

COMMENTS BY CHIEF OF ENGINEERS ON NATIONAL BITUMINOUS CONCRETE ASSOCIATION LETTER, JANUARY 8, 1958, TO MR. JOHN J. COURTNEY, SPECIAL COUNSEL, SUBCOMMITTEE FOR SPECIAL INVESTIGATIONS OF HOUSE ARMED SERVICES COMMITTEE

1. Quote Mr. Griffith: "Certainly the Australians are not any smarter than we are in this country, although it seems they can build asphalt airfields to accommodate their heaviest aircraft and also our own B–52's."

OCE comment: The statement in the Engineering News-Record specifically referred to by Mr. Griffith is: "The runway and accompanying taxi strips are designed to carry heavy aircraft, similar to the 200-ton United States Air Force B–52." In General Wilson's testimony before the subcommittee in July, it was pointed out that the Corps of Engineers had not developed valid design procedures for flexible pavement taxiways or runway ends. The Corps of Engineers design procedures for runway interiors are believed adequate. The forthcoming test at Columbus is being conducted to establish whether or not a contractor in the field can construct pavements to the design standards developed at the Flexible Pavement Laboratory, Vicksburg, Miss.

The basis for General Wilson's statements that flexible pavements are not adequate for taxiway traffic or for other paved areas where traffic conditions are severe is twofold. First, a significant number of cases of flexible pavement distress have occurred on taxiways at active airfields throughout the United States under the loadings of the lighter B–47 aircraft. Second, accelerated traffic tests at Vicksburg have failed thus far to develop an asphaltic concrete pavement capable of carrying channelized traffic for the B–52 loading.

The above discussion does not say that a limited number of B–52 aircraft would cause failure in flexible pavements designed in accordance with criteria developed to date. It does not say that certain flexible pavements under very favorable construction and climactic conditions would fail even under a 10- to 20-year full-scale operation of B–52 aircraft. It simply indicates that flexible pavement distress in certain traffic areas is a strong possibility under B–52 loading and that such failures would require a shutdown of aircraft operations in order to effect repairs. The United States Air Force informs us that the cost of such "shutdown" can far exceed the cost of pavement repair and could create a critical obstacle to the performance of their mission in time of emergency.

The Chief of Engineers makes every effort to stay abreast with the development of airfield pavement design methods developed by engineers both in this country and in foreign countries. We agree with Mr. Griffith that "the Australians are not any smarter than we are." We also believe that the pavements being constructed in Australia may well be designed to carry aircraft "similar to a 200-ton B–52" but the chances of their performing (particularly on the taxiways and runway ends) over a long period of time and under the sustained loading of a 250-ton B–52 are certainly not good.

2. Quote Mr. Griffith: "I am enclosing another document which was presented at the International Air Transport Association Conference in Florida recently. It indicates that the Department of Defense is still obstinate in their opinions."

OCE comment: The major portion of the referenced "document" deals with a discussion of Air Force requirements for parking, service, and maintenance of

apron facilities. The discussion covers requirements for ever-increasing pavement areas, parking patterns, underpavement fuel storage and hydrant dispensing systems (the accompanying problem of making the grid system of the dispensing system coincide with the parking patterns of several aircraft types), underapron electrical energy systems, tiedown rings (mooring anchors), fire hydrant systems, and maintenance problems from debris, bolts, nuts, wire, tools, etc. These discussions are factual and give an excellent concept of the problems that must be solved in addition to the pavement design itself on apron facilities.

The only portion of the paper dealing with material which might, in Mr. Griffith's mind, represent "obstinate opinions" on the part of the Department of Defense occurs in paragraph 3 under the heading "Types of Pavement." The first part of this paragraph gives a summary of factors leading to the decision by the United States Air Force to use portland cement concrete pavement in critical areas and in this case in apron facilities. The discussion is again factual with regard to dates and factors involved. The subcommittee agreed to the classification of aprons as "critical areas" in 1954.

One statement near the end of the paragraph in question represents the position of the United States Air Force in the current series of hearings before the subcommittee. This statement is quoted. "Since that time [1954], despite additional tests and experience with asphaltic pavements, including the development of a tar-rubber concrete, there have been clear indications that it is impossible to construct a flexible pavement of uniform quality throughout its multilayered system, and because aircraft continued to increase in size and weight, the previous determination that all primary-use pavements would be constructed of portland cement concrete was substantially reconfirmed."

The Chief of Engineers generally supports the above statement. However, the following comments are believed pertinent:

(*a*) The previous determination concerning all primary-use pavements was an Air Force determination made in December 1955 and it is our understanding that the subcommittee did not participate in this decision.

(*b*) The Chief of Engineers supports the use of portland cement concrete pavement in critical areas (aprons, 1,000-foot runway ends, warmup pads, and jet engine test stands). We also support the United States Air Force in their mandatory use of portland cement concrete pavements on certain other primary-use pavements (heavy-load taxiways). We do not support the United States Air Force on the mandatory use of portland cement concrete in runway interior primary-use pavements but this decision will remain in force until the results of the forthcoming Columbus AFB tests have been determined.

(*c*) The use of the word "impossible" in connection with the construction of flexible pavements is believed unfortunate. Even with regard to heavy-load taxiways in the primary-use pavement system, a construction classification such as "questionable" or "uncertain adequacy" would be a more realistic description.

Mr. COURTNEY. Mr. Chairman, this morning we have Mr. Ferry, of the Department of Air Force with his assistants here, military and civilian, and Brigadier General Brown, Assistant Chief of Engineers for Military Construction, who will bring the committee up to date on what has occurred since August 14, the last report of the subcommitte on this subject, and with graphs, detail the plan and program for the test to be conducted at Columbus, Miss.

General Brown does not have a prepared statement. He will speak from notes, using the graphs which are in the room.

Mr. HÉBERT. General Brown.

General BROWN. As Mr. Courtney had indicated, we and the Air Force were directed by your committee to meet and establish a testing program to prove or disprove the validity of Corps of Engineer design criteria for heavy-load flexible runway interior pavements.

Such a program has been established on a portion of the runway pavement currently being constructed at the Columbus Air Force Base in Mississippi.

We and the Air Force held a series of meetings at which the two basic phases of this test program were discussed in detail and agreed upon. These two phases are first the pavement design and second the details

of the test program necessary to simulate a 20-year pavement life under the traffic of B–52–G aircraft.

The details of this program as established were reported to the committee, and announced to those organizations which were represented at the hearings in June and in July.

Following this, the representatives of these organizations were invited to the meeting, design meeting in Atlanta, Ga., held on the 23d of October. All the agencies participating in that design conference were invited to submit recommendations or comments, not only on the plans and specifications of the test sections, but on the proposed testing procedure.

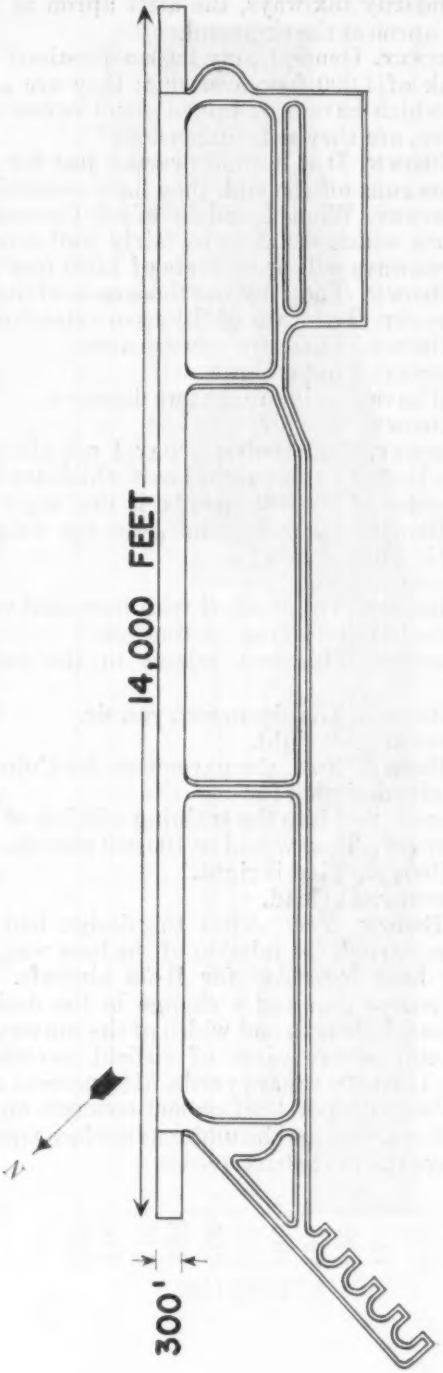
To date, the Portland Cement Association and the Asphalt Institute are the only pavement industry organizations that have formally presented comments to the Corps of Engineers.

Before discussing the comments of the industry representatives, I feel it may be appropriate to prevent graphically the layout of Columbus Air Force Base pavements, to discuss briefly existing foundation conditions, and other details of construction.

For this purpose, I have a series of charts for presentation.

My first chart, Mr. Chairman, presents merely an outline drawing of the airfield pavement as are being constructed at Columbus.

You will notice the primary runway, 12,000 feet long, 300 feet wide with 1,000-foot overruns.


AIRFIELD PAVEMENTS
COLUMBUS, AIR FORCE BASE, MISSISSIPPI
14,000 FEET
300'

The secondardy taxiways, the alert apron at the left end, and an operational apron at the right end.

Mr. COURTNEY. General, may I ask a question?

You speak of 1,000-foot overruns: they are additional to the end pavements which have been talked about before in meetings with the subcommittee, are they not—extensions?

General BROWN. It is normal practice just for emergency purposes. If someone runs off the end, they have something to go on.

Mr. COURTNEY. What I had in mind, General: there is an established criteria which seems to be fairly well accepted which says the end of the runways will be concrete of 1,000 foot lengths.

General BROWN. These are not those ends of the runways.

Mr. COURTNEY. These are additions or extensions.

General BROWN. These are overrun areas.

Mr. COURTNEY. That is right.

So we will have that in mind as we discuss it.

General BROWN. Yes, sir.

Mr. COURTNEY. And General, may I ask also: having in mind we speak of the B–52–G, the weight loads which are under discussion now are on the order of 264,000 pounds, is that right?

General BROWN. 240,000 pounds, was the weight that we discussed in June and in July.

Mr. COURTNEY. Yes.

General BROWN. The B–52–G with increased weight goes to 265,000 pounds on the heaviest of the landing gear.

Mr. COURTNEY. This test relates to the requirements for that B–52–G.

General BROWN. That is correct, yes, sir.

Mr. COURTNEY. All right.

General BROWN. Now, the pavements for Columbus Air Force Base were originally designed for——

B–47 aircraft tied into the training mission of the base.

Mr. COURTNEY. That would be 100,000 pounds.

General BROWN. That is right.

Mr. COURTNEY. On load.

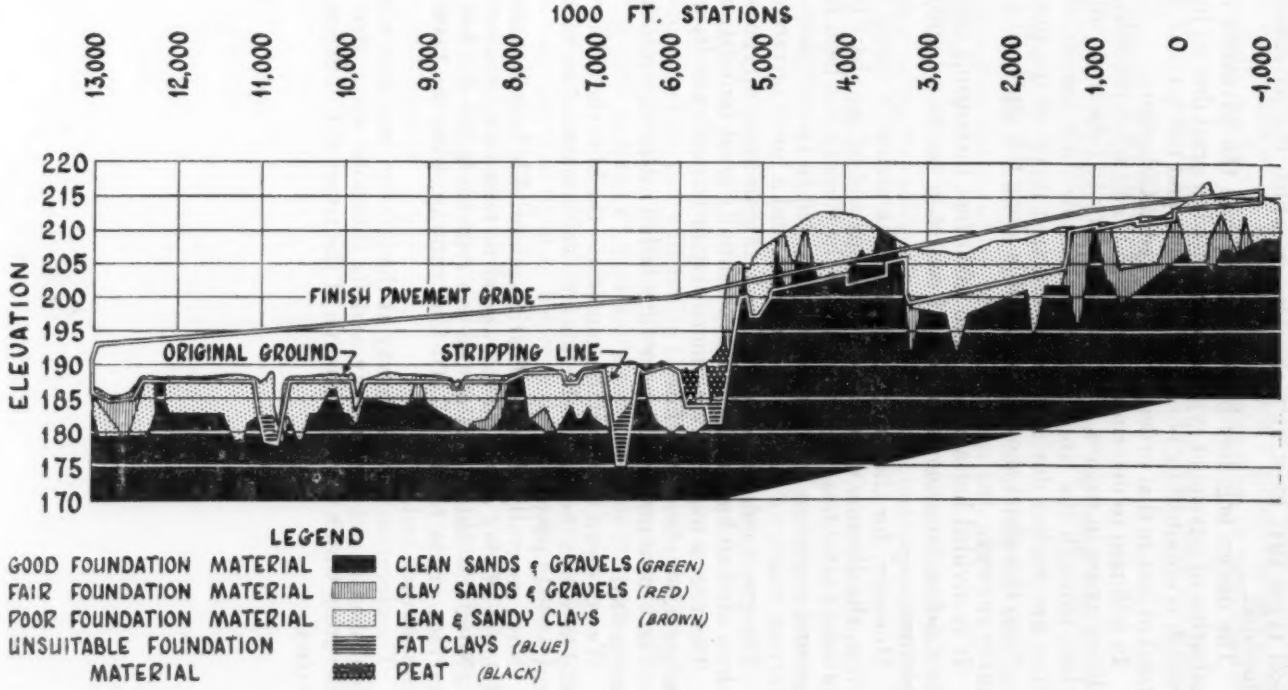
General BROWN. Yes. After the design had been completed and construction started, the mission of the base was changed to one of an operational base for SAC for B–52 aircraft. The change in the mission of course required a change in the design of the pavement, and an increase in length and width of the runway.

Of the total square yards of airfield pavement as shown on the chart, some 1,226,000 square yards, 51½ percent are currently planned to be installed with portland cement concrete and the other 48½ percent asphalt concrete and bituminous surface treatment.

May I have the next chart, please.

SOIL PROFILE FOR PRIMARY "HEAVY LOAD" RUNWAY

COLUMBUS AIR FORCE BASE, MISSISSIPPI



My next chart was prepared to give an idea of the topography and soil types that exist at Columbus on which the pavements must be founded.

The design engineer before getting into the pavement design and selection of pavement type of course needs a great deal of information, which is obtained by boring, auger holes and test pits, of which some total of 350, in that order, were executed at Columbus.

In addition to determining what soils and what the subsurface condition exists in nature, it is also necessary to take these soils and run them through the laboratory to determine their characteristics after they are worked during the construction phase of the project.

Now, this chart shows a soil profile along the center line of the primary runway.

It is divided horizontally into 1,000 foot increments and vertically into 5-foot increments, which, of course, gives us a highly distorted picture.

However, for the purposes of this discussion, it serves admirably. Now, the distance represented from one end of the chart to the other is some 14,000 feet. Now, generally the runway has been fitted into a ground condition which originally existed in two terraces—an upper terrace which we display on the right, and a lower terrace on the left.

The green color shown on the chart represents a type of material, clean sand and gravel, which is essentially good foundation material.

The red: a material with more clay or some clay to it, which is not as good, we classify as fair.

The brown material is poor foundation material, containing, again, more clay.

We get down to unsuitable material—the blue shown here, and here and here, and the black, which is unsuitable material on which to found any airfield pavement.

Now, generally the classification material is based on an increasing amount of clay as we go from good to poor to unsatisfactory.

Now, the double line at the top represents the finished pavement surface grade for the 12,000-foot runway, with its 1,000-foot overruns at each end.

The elevation of the runway at the left end was determined and established to get the runway and its shoulders above that particular elevation which the flood records of the rivers at Columbus, would not exceed.

The records show that in the last some 60 years the flood crests have exceeded an elevation of 185 feet 4 times. In November, a fifth flood occurred in which the water exceeded by some 4 inches the elevation 185, so essentially we had to get above that elevation to establish the runway.

Mr. COURTNEY. And that elevation, as I would read from the chart, is about 194.

General BROWN. Well, that is correct.

About 194 is the elevation line of the runway.

Mr. COURTNEY. The center line of the top of the completed movement.

General BROWN. That is correct.

However, with the side slope and from the center line, we must get the lowest point on the shoulder, also above this 185 feet.

Mr. COURTNEY. Yes.

General BROWN. Now, the lower double line shows the depth to which rough grading was accomplished or to which unacceptable material was removed.

The section on the right: you will notice very little material was removed, primarily because the portland cement concrete could be founded successfully on the material, with only a thin base course requirement.

Between the right end and the center, the poor foundation required removal in order to provide an adequate thickness of flexible pavement to protect the soil—the clay soils underlying from overstressing.

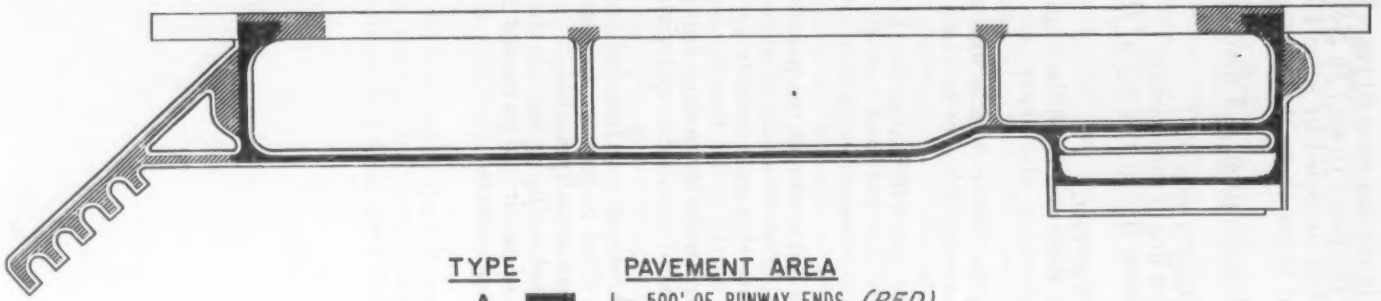
In the center section you will notice that the cut gets down to the good foundation material. In the left section from the center: except for removing those patches of unsuitable material, the stripping was very minor.

The strength of the pavement was founded on a higher strength foundation soil, that was filled in between this stripping line and to the point where the pavement actually started.

Our purpose, as I indicated in displaying this chart, was to point out primarily that the design of an airfield pavement requires a thorough study of what exists on the site selected.

My next chart, please.

TRAFFIC AREA TYPES



TYPE		PAVEMENT AREA
A.	■	1ST 500' OF RUNWAY ENDS *(RED)* PRIMARY TAXIWAYS
B.	▨	2ND 500' OF RUNWAY ENDS *(SHADED RED)* SECONDARY TAXIWAYS ALERT TAXIWAY AND PARKING WARM-UP APRONS
C.	□	RUNWAY INTERIOR *(BLUE)* PARKING, SERVICE & MAINTENANCE APRONS

This chart is designed to show the committee those areas, pavement areas that are built of the three types of general pavements that we build. By type, the traffic areas types, namely, A, B, and C.

Now, the basic factors in the design of either flexible or rigid pavement that are ground by the design engineer into the design of the pavement are the loads, the traffic frequency, and the traffic distribution on the pavement.

Now, type A pavement has a severe combination of these three factors—in other words, a high load, high traffic frequency, and a confined traffic distribution. The type A traffic areas are a portion of the first 500 feet of the runway ends [indicating]—this area and this area, and all the primary taxiways.

Now, shown in shaded red are the type B areas. These areas—using the same factors—can be defined as areas where we have a high load and either a low traffic frequency combined with a confined traffic distribution or a high traffic frequency combined with a wide traffic distribution.

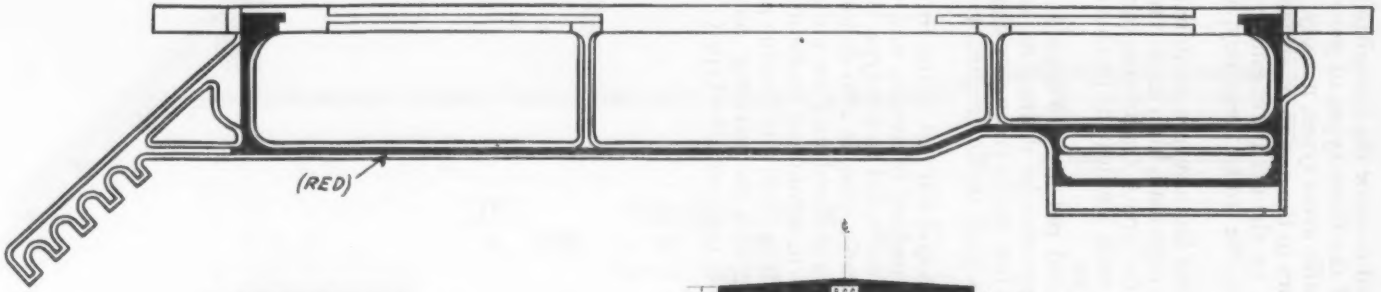
You will notice the second 500 feet of the runway ends [indicating] warm up areas, the secondary taxiways, and the alert taxiway and parking facility, are constructed to the type B traffic area.

Type C, our third traffic area, is also defined by two sets of conditions. The loading is reduced and we either have a combination of low traffic frequency in a confined traffic distribution pattern or a high traffic frequency with a wide distribution pattern.

The runway interior and the parking, service, and maintenance aprons as shown in blue, represent the type C traffic areas.

My next chart, please.

TYPE "A" TRAFFIC AREAS
RIGID PAVEMENTS



OVERLAY OF EXISTING FLEXIBLE PAVEMENT

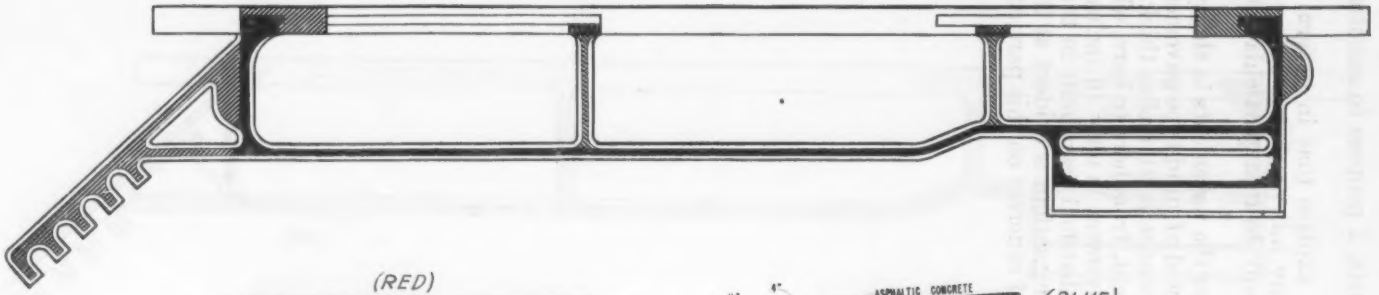
In the next series of charts, I propose to essentially construct the airfield.

This first chart—I must explain that in general I don't attempt to compare the colors on my soil pavement or my soil profile with this. The colors pertain only to that particular chart at which we are looking.

Now, this first chart shows the pavements in the type A traffic area and they will all be constructed of rigid type pavement.

The concrete in this pavement is 21 inches thick. There is a section of type A rigid pavement, from here to here, which we show in a little lighter red. That pavement is only 16 inches thick because it is founded on a pavement that had been built in the past and, therefore, the foundation is stronger than is evident at the other end. We only had to put 16 inches of concrete on this particular section of the type A traffic area.

TYPE "B" TRAFFIC AREAS

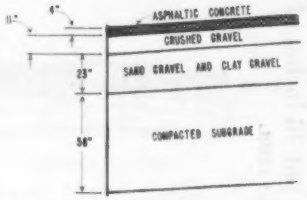


(RED)

TYPE "A" RIGID — TYPE "B" RIGID

LONGITUDINAL SECTION — RUNWAY

(BLUE)



TYPE "B" FLEXIBLE TAXIWAY

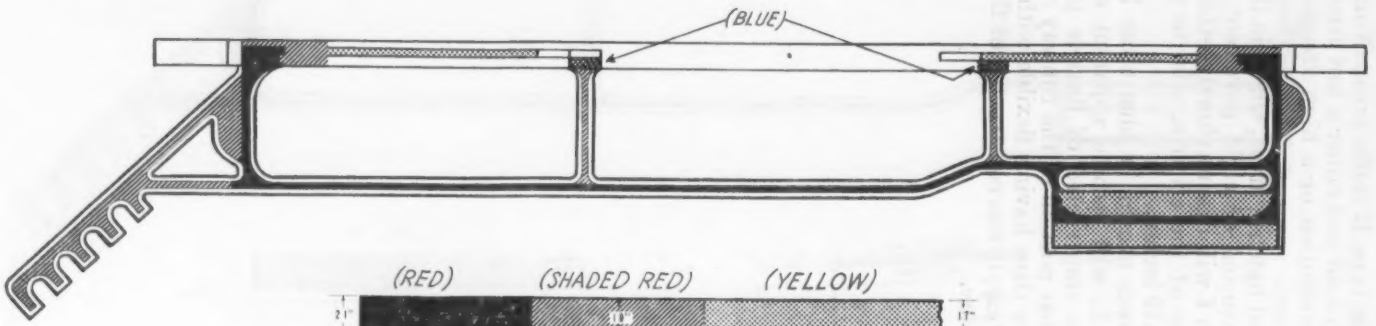
This chart adds the type B traffic area. You will recall that type B again has the high load and either a low frequency combined with a confined traffic distribution or a high frequency combined with a wide traffic distribution.

We add now the red hatched areas, where in this case the pavement thickness, also constructed of rigid pavement, except for the blue cross hatching which I will discuss shortly—this pavement is only 19 inches thick, because of the criteria, able to reduce the pavement thickness from 21 to 19 inches.

The two small areas shown in blue cross hatching are type B flexible pavement. It will become apparent as we proceed in the charts why this was constructed of flexible pavement. The areas essentially exist in that portion of the runway constructed of flexible pavement and, rather than having flexible with a little dab of rigid in these two small areas, it was constructed of flexible pavement.

The next chart, please.

TYPE "C" TRAFFIC AREAS
RIGID PAVEMENTS



TYPE "A" + TYPE "B" + TYPE "C"

LONGITUDINAL SECTION —— RUNWAY

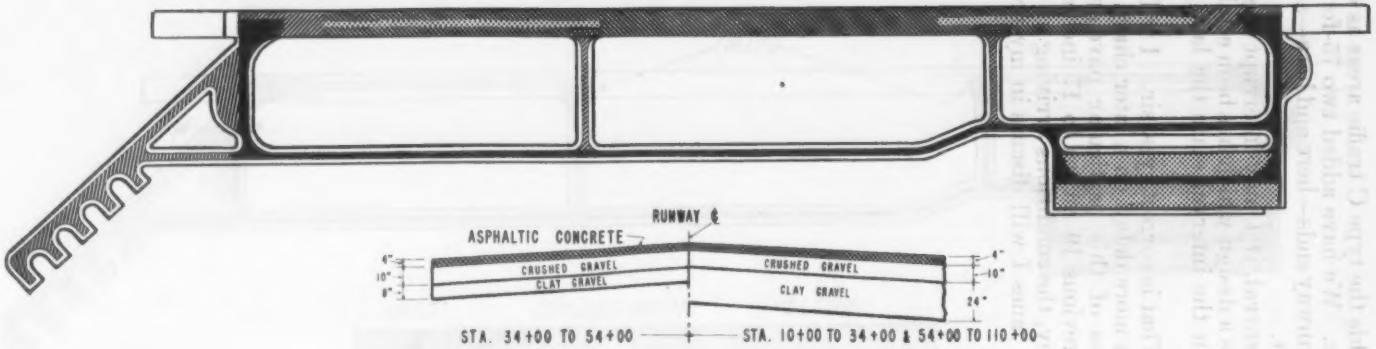
Now, this chart adds the type C traffic areas as constructed in portland cement concrete. We have added two 75-foot-wide traffic lanes, extending from the runway ends—here and here—and the service apron indicated on the right.

Mr. COURTNEY. General, if I may interrupt there, when you speak of "adding it," that is a design which has been established by the corps and the Air Force in the interval since the last presentation before the subcommittee?

General BROWN. That is correct; yes, sir. I will explain the reason for the traffic lane in more detail on a later chart.

Now, the thickness of this particular pavement again has been reduced from the previous 19 inches to 17 inches. And, as I indicated to Mr. Courtney, the conditions arriving at the decision to construct the two traffic lanes I will discuss in my next chart.

TYPE "C" TRAFFIC AREAS
FLEXIBLE PAVEMENT



TYPE "C" FLEXIBLE (REDUCED STRENGTH)

RED
BLACK
BLUE
YELLOW

Now, this chart adds the type C traffic areas constructed of flexible pavement. I had already on the last chart put the two traffic lanes in. We now add the black and white hatched areas, the yellow being constructed in rigid pavement and the black and white in flexible pavement.

You will notice in this chart now how the two blue and black cross-hatched areas of flexible pavement fit in the black and white flexible pavement areas.

Mr. COURTNEY. General, essentially what you have done on those blue areas is compact—go down deeper, isn't it, the foundation?

General BROWN. It is a little stronger design.

Mr. COURTNEY. Yes.

General BROWN. Because of being a type B traffic area rather than a type C traffic area it requires a different thickness in the base and subbase materials.

Now, initially all of the interior, 10,000 by 300 feet, of runway was designed of flexible pavement. However, during the construction it was found that the clay gravel material placed as a subbase had a lesser strength than had been assigned to it by the design.

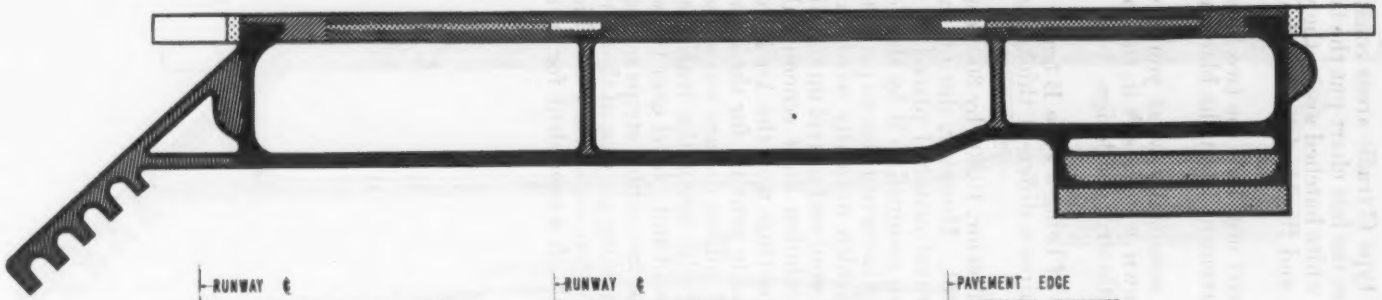
Therefore, it was necessary to correct this to provide a full-strength, type C, flexible pavement, which normally would have required the addition of some 9 inches of sand and gravel on top of what we had.

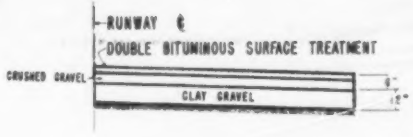
In order to arrive at a solution most economical to correct this deficiency, after a series of meetings with the Air Force, it was decided to modify the pavement plan to provide for these two traffic lanes of rigid pavement. Some half million dollars was saved in this process, in correcting the deficiency—by using the traffic lanes rather than adding the full 9 inches of sand and gravel over the whole area.

Now, the addition of these two center strips or traffic lanes with a higher strength than the remaining portion of the runway interior was strictly a matter of construction expediency on this particular job, and does not essentially establish a precedent for future construction.

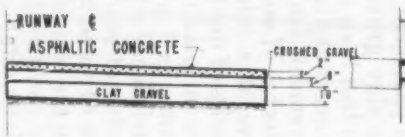
Next chart, please.

RUNWAY OVERRUNS WITH BLAST PADS AND TAXIWAY SHOULDERS





RUNWAY OVERRUN



RUNWAY END-BLAST PAD

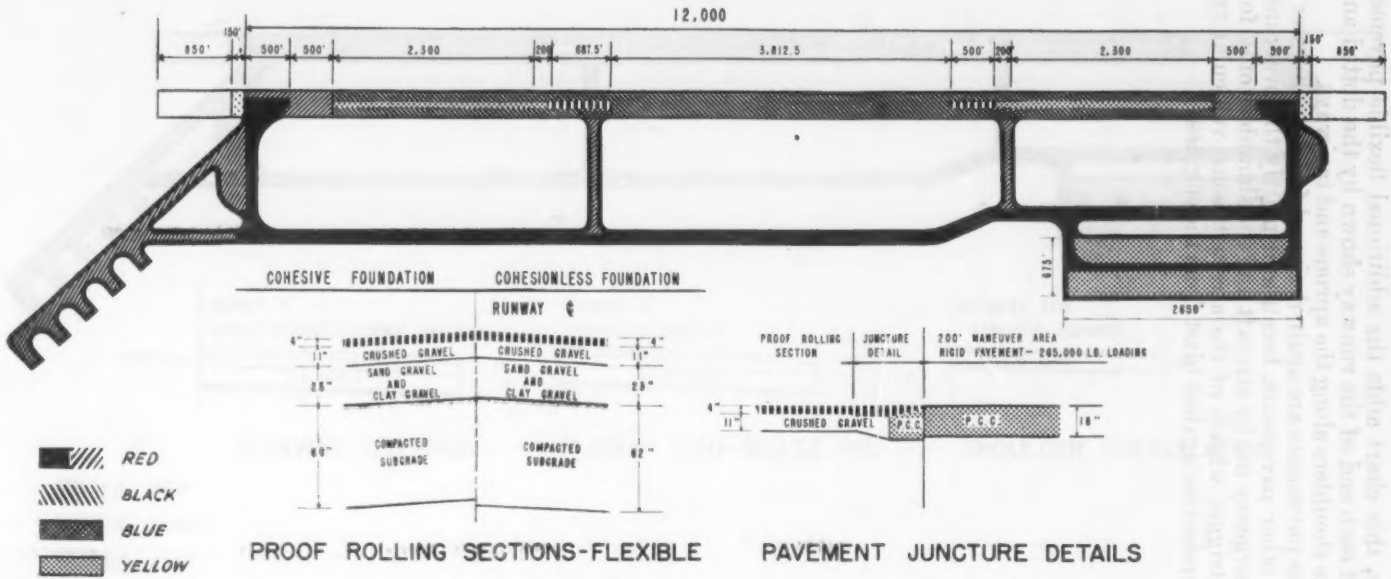
SHOULDER STABILIZATION

RED
BLACK
BLUE
YELLOW

Now, this chart adds the additional flexible pavements, the overruns at each end of the runway shown by the dotted and white areas, and the shoulders along the aprons and taxiways.

These pavements are again designed for a much lesser load than any of the other pavements, because primarily the overruns provide only for emergency use by aircraft and the shoulders only for the traffic of the outrigger wheels of the aircraft, some vehicular traffic, and also some protection against blast from the engines.

PROOF ROLLING SECTIONS
FLEXIBLE 265,000 LB LOADING



PROOF ROLLING SECTIONS-FLEXIBLE

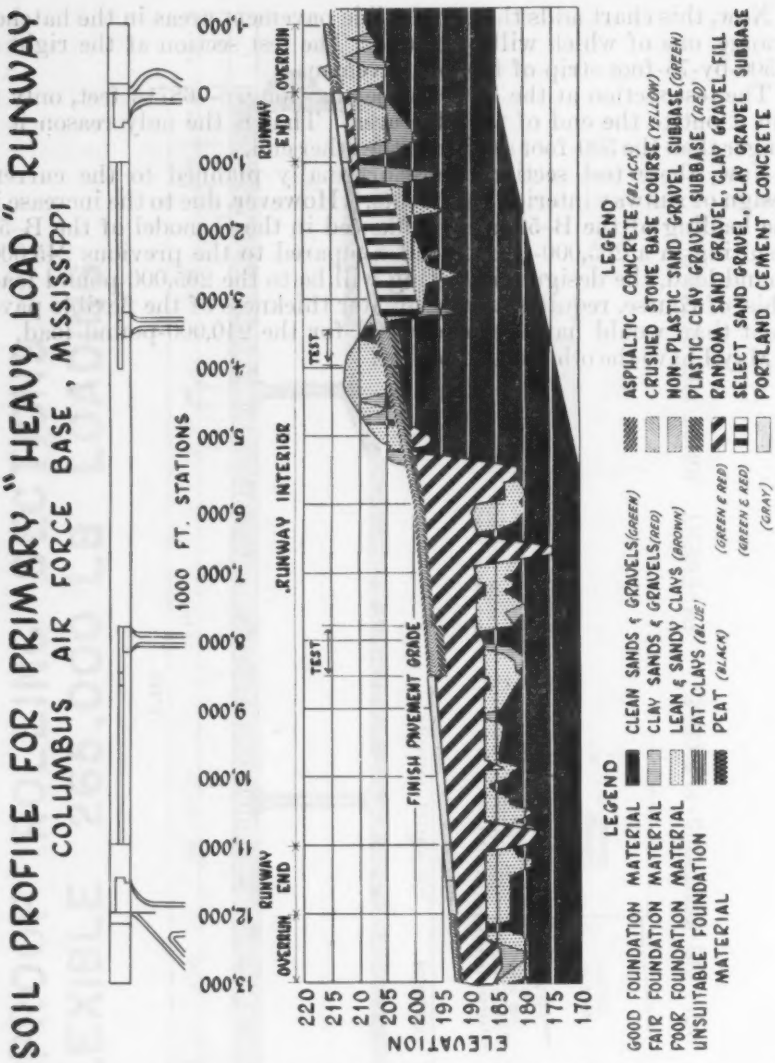
PAVEMENT JUNCTURE DETAILS

Now, this chart adds the two flexible pavement areas in the hatched orange, one of which will be tested. The test section at the right is a 500-by-75-foot strip of flexible pavement.

The test section at the left is somewhat longer—687½ feet, only to run it out to the end of the blue area. That is the only reason it is longer than the 500-foot section at the other end.

Now, these test sections were originally planned to the current design of runway interior pavements. However, due to the increase in the loading of the B–52, as is evidenced in the G model of the B–52, resulting in a 265,000-pound load compared to the previous 245,000-pound load, the design and testing will be to the 265,000-pound load. This, of course, requires a little greater thickness of the flexible pavement than would have been required for the 240,000-pound load.

May I have the other chart, please?



I have shown the soil conditions that existed, the traffic areas by types A, B, and C—how they all fit into the completed runway job.

Now, I have added an overlay to the soil profile to show what we end up with. You will notice the asphalt pavement on the interior of the runway, the 2 test sections here and here, the concrete, 21-, 19-, 17-inch thickness, and concrete at this end, the asphaltic pavement on the overrun, and a surface treatment further on the overrun and actually, the soil conditions as were in our plan to be put into place prior to the final topping of concrete or asphaltic concrete.

We had informed the committee previously, Mr. Chairman, that the test would start on or about the 1st of April. However, due to poor construction weather since September, it appears necessary that the start of the actual test may be delayed as long as the 15th of May.

We hope we can regain that time, but we aren't sure. So, it might be the start of the actual test rolling may be delayed until May 15.

Mr. COURTNEY. That is because the weather interfered with this construction you are showing?

General BROWN. Yes, sir. The weather hasn't been conducive to continuous construction.

I would like to discuss now the details of the tests, upon which we have agreed with the Air Force as being as nearly representative as is feasible in a test of this type.

Now basically the requirements were established as a result of years of study and the observation of the relationship of a short time test with the actual performance of the runways under airfield traffic over a period of years.

Before finally establishing the loading conditions, a thorough review and analysis was made of all the available data on operating weights of B–52 aircraft, on traffic frequencies and traffic-distribution patterns, the amount of lift on the aircraft at various distances after the takeoff run has started, the effect of elevation and of temperature on the lift factor, and finally the effect of the speed of the aircraft.

Much of this data was obtained through a series of conferences with the Wright Air Development Center of the Air Research and Development Command and aircraft operational personnel from the Strategic Air Command.

Most of it also is classified and could not have been made available to the industry. Before outlining the actual loading conditions, I would like to reiterate that the test pavements at Columbus are for a type C traffic area in a runway interior.

Briefly, the traffic test loading and volume of traffic is as follows.

We will have a load cart equipped with 1 of the 4-wheeled plane landing gears of the B–52 aircraft. This cart will carry a load of 212,000 pounds on the 4-wheeled gear.

Now this 212,000 pounds is 80 percent of the 265,000 pounds and is equivalent, considered equivalent to the 265,000 pound B–52 with a factor of speed and lift taken into account.

The tires of the test rig will be inflated to the pressure normally used by the Air Force with a 265,000-pound maximum loading.

The test areas will receive 5,000 traffic coverages or passes over each point in the test area. It is based on the best available data, on the distribution of B–52 traffic during landing and takeoff operations and we feel it is representative of the number of stress repetitions a pavement would be required to undergo during a 10- to 20-year operational period under B–52 aircraft.

I would like to point out at this time that the Portland Cement Association and the Asphalt Institute have taken directly opposite views relative to the validity of our traffic-test procedure.

The one feels that the loading conditions are not sufficiently severe, while the other feels that the loading conditions are too rigorous.

Mr. HÉBERT. Which, General? Identify them.

General BROWN. The Portland Cement Association feels that the loading conditions are not sufficiently severe and the Asphalt Institute indicates the loading conditions are too rigorous.

Mr. COURTNEY. Then the choice you made, General, is based upon the information you received about the operational requirements of

a B–52, including the classified material, and the other engineering data available to you as engineers and represents your engineering judgment in the circumstances?

General BROWN. That is right; also the judgment of our people which is concurred in by engineering consultants both of the Air Force and of the Corps of Engineers.

The Portland Cement Association letter of November 15, signed by Mr. James D. Piper, vice president for promotion—in that letter we have underscored certain comments which show the Portland Cement Association to believe that the foundation conditions in the test section are extremely good and far better than could normally be expected.

They point out further that the B–52 loading conditions are too light for such a test, in view of possible future aircraft loadings currently being studied in the pavement investigational program.

Now, in contrast to this, the first letter from the Asphalt Institute, signed by Mr. Arvin S. Wellborn, points out that the slow-moving traffic is far more severe on flexible pavements than the high-speed aircraft traffic occurring during takeoff and landings and that the design loading of the aircraft should be reduced by one-third for such a test.

Now, in a second letter from the Asphalt Institute, they presented some 16 recommendations which we have considered on a basis of merit and will incorporate in the Columbus project, either in the construction or in the test when we feel that the point was well taken.

Now, of these 16 specific recommendations, 12 are either already existing as part of our specifications or have been adopted by us by modification. In other words, 12 out of the 16.

Two additional recommendations will probably be adopted depending to some extent on the resolution of other considerations. And finally, two of the recommendations will not be used.

Mr. COURTNEY. General, these letters to which you have reference and from which you have quoted and on which you have commented are part of the presentation. Mr. Chairman, I would ask that they be included as a part of the record at this time.

Mr. HÉBERT. Without objection, they will be included.

(The documents above referred to are as follows:)

PORTLAND CEMENT ASSOCIATION,
Chicago, Ill., November 15, 1957.

Maj. Gen. W. K. WILSON, Jr.,
Deputy Chief of Engineers for Construction, Office of the Chief of Engineers, Department of the Army, Washington, D. C.

DEAR GENERAL WILSON: Acting upon your invitation and that of the division engineer, South Atlantic Division, we participated in the conference held at Atlanta on October 23, 1957, which provided information and discussion on the forthcoming traffic tests on flexible pavement at Columbus Air Force Base, Miss.

Our representatives report that the conference was extremely well conducted with full opportunity afforded for discussion of design criteria, construction features, and test conditions. We deeply appreciate the courtesies extended our people and the opportunity of expressing our comments at the meeting. It does seem regrettable that the principal user of heavy-duty pavement, Strategic Air Command, did not have representatives at the conference.

In accordance with the invitation extended in your letter of October 2, the following comments regarding design and test of the pavement are presented for your consideration.

After further study and analysis of the pavement design and test conditions, it is the consensus of our engineers that the scheduled test can prove only one thing: That is whether or not this particular section of bituminous pavement

can withstand 5,000 coverages of simulated B–52 gear loading under the very unusual conditions of design and construction existing at Columbus Air Force Base.

It develops from the description of the test sections which was provided by the Mobile district engineer that the total thickness of flexible pavement is 25 inches for the surafce, base, and subbase. There are, however, additional thicknesses of compacted subgrade. These layers of compacted subgrade are actually gravelly in nature, even on the filled sections where it is indicated that the material is cohesive. The total thickness of gravel subgrade and pavement is at least 98 inches on the fill section and 100 inches on the cut section. Inasmuch as this thickness of good gravel will rarely, if ever, be found on a typical airfield, it is doubted that the Columbus test location can be considered representative of an average condition.

As we see it there are two major factors which determine the service life of a flexible pavement. First, there is the design and placing of the wearing surface which in itself should be stable and durable. Second, and of equal if not greater importance, is the amount of deflection and rebound that will develop under repeated loadings. The greater the deflection, the quicker fatigue and cracking will develop. Any deep layers of gravel such as exist at Columbus—and at few, if any, other airfields—will reduce the resilience of the entire pavement structure and will have a definitely beneficial effect upon the flexible surface. This condition will not be duplicated on an airbase located on a less favorable foundation. Therefore, because of natural conditions at this airbase, it appears that one of the major factors causing distress in flexible pavements has been eliminated. It is questionable whether the test results can logically be applied to any location other than Columbus, Miss.

There is another feature of the design of the test sections which appears open to question. It is specified that the binder and surface course mixtures shall be reduced 20 percent below the optimum asphalt content. This reduction in bitumen in order to provide stability for the heavy test rig will, according to testimony of Corps of Engineers witnesses at the congressional hearings, reduce the durability of the surface. Any reduction in life expectancy of a pavement type not noted for its durability under heavy wheel loads might be considered a measure which will provide a troublesome and expensive criterion for future Air Force pavement construction.

We would like to refer to the waterways experiment station brochure entitled, "Accelerated Traffic Testing for Proof Testing Flexible Pavement Design at Columbus Air Force Base."

On page 1 under the heading, "Test Conditions," the following condition is set forth: "(*d*) *Temperature.*—Start traffic between April 1 and 15, 1958; continue traffic as nearly as possible for 24 hours a day until 5,000-coverage level is reached, except that when traffic above 90° accumulates to the equal of the prototype temperature experience, traffic will be cut off when temperatures above 90° are reached." This statement has the effect of establishing a maximum number of coverages to be applied at 90° or higher. It appears that if the temperature conditions at Columbus are to be reflected in the test results, there should be established a minimum number of coverages that will be applied at temperatures of 90° and higher. It is felt that the accumulated test traffic at above 90° should represent a percentage of the total traffic applied in the same ratio as shown by prototype temperature experience.

The test rig will not have bicycle landing gear arrangement and will not duplicate the rolling effect of the B–52, particularly with regard to its tendency to porpoise. While Mr. C. R. Foster explained the impractibility of duplicating the gear arrangement and speed of the B–52 on the test at Columbus, it is felt that there is a corollary consideration which should be given complete evoluation in the test results. Operating personnel of the Air Force have found that any deviation from grade alinement or significant lack of surface smoothness may induce porpoising action in jet bombers which becomes drastic and dangerous. It is strongly felt, therefore, that any appreciable deformation of the flexible pavement during the progress of the test should be interpreted as a failure of the pavement, since such deformation renders the pavement unsuitable to serve the purpose for which it is being tested. Should not a predetermination be made of the amount of deformation that will constitute failure?

During the recent congressional subcommittee hearings, witnesses of both the Air Force and Corps of Engineers mentioned a probable future requirement for airfield pavement to carry a 325,000-pound gear load on tires inflated to above 300 pounds per square inch. It should be pointed out that any bituminous

pavement that may be designed and built as a result of the Columbus test will become completely obsolete when this load requirement becomes a reality. There is no design criterion now in existence under which an existing asphaltic pavement could be converted to meet such a load requirement.

The question naturally arises, Why test a design which is obsolete for planes of the immediate future when the result of the test will likely determine national policy?

We are planning to follow closely the progress of construction and testing of the pavement at Columbus. We will provide you with such further comments as are indicated by our observations.

Yours very truly,

JAMES D. PIPER,
Vice President for Promotion.

THE ASPHALT INSTITUTE,
EXECUTIVE OFFICES AND LABORATORIES,
UNIVERSITY OF MARYLAND,
COLLEGE PARK, MD., *November 13, 1957.*

CHIEF OF ENGINEERS,
Department of the Army,
Washington, D. C.

DEAR SIR: By letter dated September 27, 1957, to Mr. J. E. Buchanan, president of the Asphalt Institute, Maj. Gen. W. K. Wilson, Jr., requested that our comments and recommendations regarding the forthcoming runway tests at Columbus, Miss., AFB be transmitted to you for consideration. The purpose of this letter is to present to you such comments and recommendations, based on information presented to us at a Corps of Engineers conference held in Atlanta, Ga., on October 23, 1957.

First, may we call attention to testimony by General Wilson in hearings before the Subcommittee for Special Investigations of the Committee on Armed Services, House of Representatives. Specific reference is made to General Wilson's testimony appearing on page 2318, Subcommittee Proceedings No. 5, Airstrip Paving Materials, dated August 14, 1957. In this testimony, General Wilson wisely recognized some of the difficulties which would be encountered in setting up an accelerated testing procedure which would adequately represent conditions of prototype traffic on the interior portions of runways. This is the condition to be represented by the Columbus AFB tests, according to information disseminated at a Corps of Engineers conference noted above.

Specifically, General Wilson pointed out that planes would be partially airborne when they reached the flexible pavement interior portion of the runway. At the Atlanta conference, a statement was made to the effect that the speed of the plane at this point on takeoff run would be approximately 100 knots. We have no way of verifying the accuracy of this figure or of estimating the decrease in landing gear load resulting from wing lift at such a speed. It would appear, however, that the load decrease would be substantial.

General Wilson further pointed out that in landing operations the planes would not be fully loaded. It might also be added that cold temperatures for the high altitudes at which these planes normally operate might reasonably be expected to reduce the tire pressures.

Another factor mentioned at the Atlanta conference was that in current SAC operations only about 25 percent of the planes take off fully loaded. On the other hand, we recognize that this percentage might be increased substantially in times of national emergency. Still, considering the loadings for both the takeoff and landing conditions, full load on the landing gear should be anticipated on not more than 50 percent of the operations.

Another factor, not mentioned by General Wilson, is the effect of rapidly moving loads on flexible pavements. Asphaltic materials, because of their viscous and ductile characteristics, perform best under rapidly moving loads. Because of the inherent difficulty of conducting accelerated traffic tests with rapidly moving loads, we know of no scientific data from which a relationship of speed versus pavement performance could be derived. On the other hand, observations at many airfields have indicated that such distress as may occur in flexible pavements do so almost entirely on taxiways, aprons, and other areas where planes move slowly. This is so despite the fact that in many instances the interior of the runways were designed for lesser wheel loads than areas for

slowly moving traffic. The superior pavement performance on the interior of the runways is likely due to at least two factors:

1. Decrease in landing-gear load due to wing lift.
2. Inherent ability of asphaltic materials to resist the shock or impact effects of rapidly moving loads.

We believe that the factors outlined above are the principal ones to be borne in mind when establishing the accelerated traffic testing conditions to be followed in the Columbus AFB tests. It is readily apparent that there is no exact answer to this problem. The solution reached must represent the best engineering judgement of all concerned and one which will provide truly representative findings.

Information presented at the Atlanta conference was to the effect that interior of runway traffic would be simulated in the Columbus test by 5,000 coverages of a 265,000-pound landing-gear load, reduced by 20 percent for the runway traffic test presumably to offset to some extent the effect of wing lift. This results in a 212,000-pound load on 4 wheels, at a tire pressure of 266 pounds per square inch. It would appear that this represents the consensus of your office and the Air Force as to takeoff loadings anticipated for the flexible pavement interior portion of the runway. If so, may we respectively inquire as to the basis for this decision. It would appear that a reasonable estimate of the landing-gear loads could be made by determining the average speed of the plane on takeoff when reaching the flexible pavement portion of the runway. Then, the Department of the Air Force, or the plane manufacturer, should be able to provide data on wing lift at this speed. We believe that such an analysis would provide the most logical determination of the maximum takeoff loading conditions. Information of this nature would be extremely helpful to all who are sincerely interested in a realistic appraisal of the findings of these accelerated loading tests.

We believe that consideration should next be given to the effect of the rate of speed at which a load is applied to an asphalt pavement, entirely separate and apart from winglift effects. In considering this factor, it must be recognized that factual data are nonexistent and reliance must be placed almost entirely upon engineering judgment.

In the laboratory, it can be demonstrated by a thin-film, shear-type viscosity test that shear movement of a typical asphalt is a function of the magnitude of load and the time during which the load is applied. For most asphalts, the total shear movement is directly proportional to time. Thus, considering only the asphalt phase of the paving mix, doubling the rate of speed of the moving vehicle could be expected to reduce shear movement by one half. To bring the picture more nearly into perspective, assume that a plane taking off has reached a speed of 100 knots when it reaches the flexible pavement section and that the speed of the load cart is 5 knots. It could then be roughly estimated that shear displacements would be on the order of magnitude of 20 times greater under the load cart than under the rapidly moving plane. Or, again roughly, it would require 20 passes of the rapidly moving plane to cause the shearing displacement caused by one pass of the slowly-moving load cart. In presenting this analysis, we are fully aware that aggregate characteristics and gradation of the aggregate also have a bearing upon such pavement movements. The purpose of the analysis is simply to present one phase of the problem on which some data at least are available.

Perhaps the next item on which some discussion is justified relates to the number of coverages to be applied to the test section. At the Atlanta conference, it was brought out that 5,000 coverages would be applied and that this would require 20,000 passes of the load cart over a lane 14.4 feet wide. Load on the landing gear assembly would be 265,000 pounds reduced by 20 percent, or 212,000 pounds. Here again we find the need for factual data on the amount of load reduction which may be attributed to wing lift at the speed for which planes will be traveling over the interior, flexible-pavement portion of the runway. There is also a need for data on average landing loads and tire pressures as well as data on the percentage of planes which take off fully loaded. With such data, we feel that a more realistic appraisal of the 5,000 coverage level could be made.

Considering the various factors discussed above, and using engineering judgment to the extent of our capabilities where factual data are lacking, it is our considered opinion that conditions established for the accelerated traffic tests are reasonable, except for the adopted landing-gear load. We believe that a one-third reduction in the 265,000-pound gear load would still provide conservative conditions for the test.

In addition to our comments on the accelerated traffic testing procedures and conditions for tests at Columbus AFB, we also wish to make specific comments and recommendations on construction specifications for the project, as distributed at the Atlanta Conference. These will be submitted by separate letter.

Very truly yours,

ARVIN S. WELLBORN, *Chief Engineer.*

THE ASPHALT INSTITUTE,
EXECUTIVE OFFICES AND LABORATORIES,
UNIVERSITY OF MARYLAND,
College Park, Md., November 13, 1957.

CHIEF OF ENGINEERS,
Department of the Army,
Washington, D. C.

DEAR SIR: Please refer to a letter to Mr. J. E. Buchanan dated September 27, 1957, from Maj. Gen. W. K. Wilson, Jr. In this letter, General Wilson requested that our comments and recommendations on the Columbus AFB runway tests be submitted to you for consideration. In another letter of this date, our comments and recommendations on accelerating testing procedures were submitted to you. The purpose of this letter is to outline our comments and recommendations on the construction specifications for the project, distributed at a Corps of Engineers conference held in Atlanta, Ga., on October 23.

Our comments and recommendations with regard to these specifications are as follows:

1. Section 5–04 (3): This section would permit the use of an antistrip additive, based on a laboratory test which, in our judgment, is of little or no significance. It is our recommendation that aggregates used for this test section be those which have a satisfactorily proven record in highway performance and that an additive not be used.

2. Section 5–05 (a): It is recommended that a 60–70 penetration grade asphalt cement be used instead of the presently specified 85–100 penetration grade.

3. Section 5–06: It is recommended that aggregate graduation limits be established on the basis of mixes judged to be most satisfactory in accelerated traffic tests by the flexible pavements branch.

4. Section 5–07: Because of the critical nature of asphalt content in accelerated traffic tests, it is recommended that the tolerance on asphalt content for surface and binder course mixes be reduced to plus-or-minus 0.2 percent. It is further recommended that mixing temperature tolerances be plus or minus 15° F.

5. Section 5–09 (b): Recommend addition of the following: "The surface of the roller wheel shall be true; no surface irregularities will be permitted."

6. Section 5–13 (a): This section requires premixing of all coarse aggregates as well as premixing of all fine aggregates. The Asphalt Institute does not consider this to be good practice. Our publication Specifications and Construction Methods for Hot-Mix Asphalt Paving includes the following requirements:

"Coarse and fine aggregates shall be stored at the plant in such a manner that the separate sizes will not become intermixed. Cold aggregates shall be carefully fed to the plant in such proportions that surpluses and shortages in the hot bins will not cause breaks in the continuous operation. When loading aggregate into cars, barges, and trucks and onto stockpiles the material shall be placed in such a manner as to prevent segregation of aggregate sizes. Stockpiles shall be built uniformly in layers not exceeding 5 feet in depth and shall be removed for use in the same manner. Rail cars, barges, and trucks shall be loaded in uniform layers.

"Two or more fine aggregates meeting the required specifications may be blended at the cold elevator to improve the fine aggregate gradation in the mix. Similarly, two or more different gradings of coarse aggregate from the same source may be combined. Blending of aggregates in stockpiles shall not be permitted."

It is recommended that similar provisions be included in the project specifications. It is our understanding that such premixing is not permitted in some divisions of the Corps of Engineers and that these divisions have specifications which require separate cold feeds for each aggregate.

7. Section 5–14: Requires that truck beds be oiled with a thin oil. We recommend that oil not be permitted and that the following be inserted:

"The truck beds shall be painted or sprayed with a lime-water or soap solution at least once a day or as often as required. After this operation, the truck bed shall be elevated and thoroughly drained; no excess solution shall be permitted."

8. Section 5–15: It is recommended that a minimum of two finishing machines be required and that they be operated in tandem and in such a manner as to provide for a maximum of hot joints. It is also recommended that where tack coats are to be used, an Asphalt Institute grade SS–1 emulsified asphalt be required. This emulsified asphalt should be applied at a rate of 0.05 to 0.10 gallons per square yard, depending upon the texture of the surface being tacked. It should be diluted with water to achieve better application uniformity, increasing the application rate of the diluted material to provide the required amount. We also recommend a diluted material to provide the required amount. We also recommend a diluted emulsified asphalt on contact surfaces abutting the pavement. The ratio of water to emulsified asphalt should be on the order of 1:1 to 1:2. It is preferable to spray this material rather than paint it on the surface.

9. Section 5–16 (a) (1): It is understood that in addition to the 98 percent minimum density requirement, a 100 percent maximum density requirement will be added.

10. Section 5–17(a): See 8 above regarding the application of asphalt on contact surfaces.

11. Section 5–17(c): Should require that all joints be straight and true to line.

12. General recommendations:

(*a*) That further study be given to the design of the longitudinal joint between flexible and rigid pavement with a view of providing a satisfactory, watertight joint. Certain suggestions were made on this feature at the Atlanta conference.

(*b*) If asphaltic pavement is placed this fall, it is recommended that it occasionally be rolled with a rubber-tired roller until test traffic is begun. If placed next spring, it is recommended that the pavement be allowed to cure for at least 1 week. During this period, a moderate amount of rolling with a light, rubber-tired roller would be desirable.

(*c*) It is recommended that the sequence of construction be planned in such a manner as to provide proper surface drainage at all times.

(*d*) It is recommended that the base be primed immediately after construction and rolled with a rubber-tired roller.

Very truly yours,

ARVIN S. WELLBORN, *Chief Engineer.*

General BROWN. Now, in summary, Mr. Chairman, I have endeavored to point out the complexities that face us in the design of modern airfield pavement for heavy military aircraft, which is complicated by the ever-changing weights, changing traffic pattern and operational requirements, to say nothing of the variation of soil conditions on which pavements must be founded and the ever-present problem of devising methods and combinations of materials to produce an adequate and economical pavement.

The proof test at Columbus has been devised to establish whether or not a contractor on a given project can produce flexible pavements capable of performing in one of the traffic areas. In this case at Columbus, it is the runway interior. The test will provide a basis for pavement type selection on B–52 airfields.

The loading requirements, which these test pavements must withstand in a short term traffic test, have been jointly established and agreed upon by both the Corps of Engineers and the Air Force as being representative of long-time full-scale B–52 aircraft traffic.

And I would like to also reiterate in my summary that representatives of the Portland Cement Association and of the Asphalt Institute do not agree that the loading conditions are correct.

The Chief of Engineers and the Air Force have reached agreement on the test and will use the result for guidance in the selection of pavement type for B–52 airfield construction.

However, it is probable that either the asphalt or concrete industry will question and criticize the end results regardless of the outcome.

That is all I have to present, Mr. Chairman.

Mr. HÉBERT. I think your last statement, General, is perfectly obvious and apparent. [Laughter.]

Mr. HÉBERT. Mr. Hardy, any questions?

Mr. HARDY. I have no questions.

Mr. HÉBERT. Mr. Gavin?

Mr. GAVIN. No questions.

Mr. HÉBERT. Mr. Fisher?

Mr. FISHER. As I understand it, the Air Force agrees that the test conditions were proper, whereas the concrete people and asphalt people do not, is that correct?

General BROWN. That is correct; yes, sir.

Mr. FISHER. That is all.

Mr. HARDY. Could I just follow that up? I notice from your comments, I believe, General, you are agreeing with the asphalt people to a considerable extent. Did you agree with the Portland Association?

General BROWN. The Portland Cement Association letter was a general letter. It didn't make specific recommendation.

Mr. HARDY. It didn't make specific recommendations?

General BROWN. As to changes.

Mr. HARDY. But it did make specific criticisms of the basic test, did it not?

General BROWN. Yes, sir.

I have a series of comments, item by item, if you would care that I go into them.

Mr. HARDY. I don't want to go into it now. But I think it might be a good idea for us to have in the record, Mr. Chairman, any comments that engineers have to the points raised by the Portland Cement Association.

General BROWN. We can furnish our comments on both letters and in detail the comments on the specific recommendation for inclusion in the record; yes, sir.

Mr. HARDY. As I recall, one of the points made by the Portland Cement Association was that this was not a representative field and there were better subgrade conditions than would be found on the average field.

Now, I presume you must have some comment about that.

General BROWN. Yes, sir.

Mr. HARDY. So, Mr. Chairman, if there is no objection, I would like to suggest that the corps send us a copy of their comments for inclusion in the record.

Mr. HÉBERT. Do you have the comments available now?

General BROWN. Yes, sir.

Mr. HÉBERT. We don't ask you to read them; put them in the record at this point.

General BROWN. I can, yes, sir.

Mr. HÉBERT. I mean the same as you did on the 16 recommendations made by the asphalt industry. You say you eventually will put in 14 out of the 16 of the recommendations.

General BROWN. That is right.

(The comments are as follows:)

DISCUSSION BY CHIEF OF ENGINEERS OF PORTLAND CEMENT ASSOCIATION LETTER OF NOVEMBER 15, 1957, TO THE CHIEF OF ENGINEERS RELATIVE TO TRAFFIC TESTS AT COLUMBUS AIR FORCE BASE, MISS.

(Quotations from PCA letter are designated in the same manner as letters presented to the subcommittee on January 9, 1958)

a. PCA comment

"After further study and analysis of the pavement design and test conditions, it is the consensus of our engineers that the scheduled test can prove only one thing: That is whether or not this particular section of bituminous pavement can withstand 5,000 coverages of simulated B–52 gear loading under the very unusual conditions of design and construction existing at Columbus Air Force Base."

OCE discussion of PCA comment "a"

The intent of the proof test program is to determine whether or not a contractor on a given project can produce flexible pavements capable of performing satisfactorily in a runway interior. The laboratory adequacy of these pavements has already been established at the Waterways Experiment Station on a variety of foundation conditions. Any argument as to the design and construction at Columbus representing an average condition is not pertinent because no effort was made to be selective in assigning the test program to that base.

b. PCA comment

"Inasmuch as this thickness of good gravel will rarely, if ever, be found on a typical airfield, it is doubted that the Columbus test location can be considered representative of an average condition."

c. PCA comment

"Any deep layers of gravel such as exist at Columbus—and at few, if any, other airfields—will reduce the resilience of the entire pavement structure and will have a definitely beneficial effect upon the flexible surface."

d. PCA comment

"Therefore, because of natural conditions at this air base, it appears that one of the major factors causing distress in flexible pavements has been eliminated. It is questionable whether the test results can logically be applied to any location other than Columbus, Miss."

OCE discussion of PCA comments "b", "c", and "d"

Again—there was no intent for Columbus to represent an "average" condition. However, the departure from the "average" is not as great as the PCA would make it appear. The average subgrade CBR upon which the design of flexible pavements is based throughout the United States is 15. At Columbus the design CBR of the foundation for the test sections is 20. Admittedly, materials exhibiting a CBR in a range of 15 to 20 are better than the average pavement subgrade for all pavement types which is more in the order of a 10 CBR. It should be noted that flexible pavements show the greatest economic advantage on high quality foundations; therefore, the strength of the average foundation under flexible airfield pavements is somewhat higher than the overall average.

Almost all subgrades for airfield pavements in the State of Florida, for instance, are of as high quality and to as deep depths as those at Columbus. (Eglin, McDill, Pinecastle, Homestead, and Palm Beach). Many other bases throughout this country and overseas are founded on high quality foundations (Westover, Mass.; Plattsburgh, N. Y.; McChord, Wash.; Larson, Wash.; Hill, Utah; Keesler, Miss.; Loring, Maine; Goose Bay, Canada; Sidi Slimane, Morocco, and Wheelus, Libya).

In addition to the above examples, practically all of the airfields located generally north of the 42 parallel (Maine, Vermont, New Hampshire, Michigan, Wisconsin, Minnesota, North Dakota, South Dakota, Montana, Wyoming, and Idaho) require deep frost free granular foundations as protection against frost action. In Alaska and Greenland great depths (10–12 feet) of coarse granular material is often used beneath pavements as protective blanket against permafrost thaw.

d. (1) PCA comment

"It appears that if the temperature conditions at Columbus are to be reflected in the test results, that there should be established a minimum number of coverages that will be applied at temperatures of 90° and higher."

OCE discussion of PCA comment "d. (1)"

Representatives of the Chief of Engineers have agreed that specifying a minimum number of coverages at pavement temperatures higher than 90° is desirable. This comment was made by the PCA during the Atlanta Conference in October 1957 and immediately following that meeting the instructions for "test conditions" were modified to read: "* * * traffic will be controlled so that the curve of percent coverages versus [pavement] temperature equals the curve of percent [yearly] observations versus [pavement] temperature at the 90° point within 2 percentage points plus or minus."

e. PCA comment

"The test rig will not have bicycle landing gear arrangement and will not duplicate the rolling effect of the B–52, particularly with regard to its tendency to porpoise."

OCE discussion of PCA comment "e"

During the accelerated traffic tests at Vicksburg and Cincinnati for flexible and rigid pavements, respectively, load carts equipped with B–47 landing gear were pulled in tandem to represent bicycle geared aircraft. The presence of the trailing gear had no noticeable effect on the pavement so long as the additional coverages were considered. The stress produced in the pavement by the passing of the forward landing gear was not increased by the presence of a trailing gear, or vice versa.

f. PCA comment

"During the recent congressional subcommittee hearings, witnesses of both the Air Force and Corps of Engineers mentioned a probable future requirement for airfield pavement to carry a 325,000-pound gear load on tires inflated to above 300 psi. It should be pointed out that any bituminous pavement that may be designed and built as a result of the Columbus test will become completely obsolete when this load requirement becomes a reality. The question naturally arises, Why test a design which is obsolete for planes of the immediate future when the result of the test will likely determine national policy?"

OCE discussion of PCA comment "f"

The proof test at Columbus is being conducted to validate the adequacy of a flexible pavement designed for the current B–52 aircraft loading. With regard to probable future aircraft loadings portland cement concrete pavements and flexible pavements must be considered in the same category. Valid design criteria have not been developed for either pavement type, and until such time as traffic tests have been completed, the present design criteria for the B–52 loading will be obsolete in either case. Test sections composed of portland cement concrete have been constructed for the future loading condition but traffic tests are not scheduled for completion until 1960.

DISCUSSION BY CHIEF OF ENGINEERS OF ASPHALT INSTITUTE LETTER OF NOVEMBER 13, 1957, TO CHIEF OF ENGINEERS RELATIVE TO TRAFFIC TESTS AT COLUMBUS AIR FORCE BASE, MISS.

(Quotations from Asphalt Institute letter are designated in the same manner as letters presented to subcommittee on January 9, 1958)

h. AI comment

"General Wilson wisely recognized some of the difficulties which would be encountered in setting up an accelerated testing procedure which would adequately represent conditions of prototype traffic on the interior portions of runways."

i. AI comment

"Specifically, General Wilson pointed out that planes would be partially airborne when they reached the flexible pavement interior portion of the runway. At the Atlanta conference, a statement was made to the effect that the speed of the plane at this point on takeoff run would be approximately 100 knots. We have no way of verifying the accuracy of this figure or of estimating the decrease in landing gear load resulting from wing lift at such a speed. It would appear, however, that the load decrease would be substantial."

OCE discussion of AI comments "h" and "i"

Theoreitcal data on the actual lift that occurs on aircraft during takeoff runs have been developed by the B–52 aircraft manufacturers and the Wright Air Development Center of the Air Research and Development Command, and these data have been studied by both the Air Force and the Corps of Engineers. While the actual effect of speed and lift on pavement loadings is an engineering determination and must be based on judgment to a certain extent, the performance of runway pavement designed and constructed by the Corps of Engineers for lighter aircraft (B–29, B–36, B–47) has shown the approximate 20 percent load reduction for runway interiors to be substantially correct.

j. AI comments

"General Wilson further pointed out that in landing operations the planes would not be fully loaded. It might also be added that cold temperatures for the high altitudes at which these planes normally operate might reasonably be expected to reduce the tire pressures."

k. AI comment

"Another factor mentioned at the Atlanta conference was that in current SAC operations only about 25 percent of the planes take off fully loaded. On the other hand, we recognize that this percentage might be increased substantially in times of national emergency. Still, considering the loadings for both the takeoff and landing conditions, full load on the landing gears should be anticipated on not more than 50 percent of the operations."

OCE discussion on AI comments "j" and "k"

The Chief of Engineers in 1956 established a series of periodic conferences with engineers of the Air Force responsible for aircraft development and operation. In these meetings definite information was presented by SAC regarding the operational weights for their various missions, the landing weights of their aircraft and the tire inflation pressures used. These data have been accepted as the best available and were considered in establishing the loadings and traffic repetition a pavement must withstand in a test to be representative of the prototype condition. Since these data are highly classified, because by interpretation they give an idea of SAC's mission requirements, no presentation has been made to either the Asphalt Institute or the Portland Cement Association.

l. AI comment

"Another factor, not mentioned by General Wilson, is the effect of rapidly moving loads on flexible pavements. Asphaltic materials, because of their viscous and ductile characteristics, perform best under rapidly moving loads. Because of the inherent difficulty of conducting accelerated traffic tests with rapidly moving loads, we know of no scientific data from which a relationship of speed versus pavement performance could be derived."

m. AI comment

"To bring the picture more nearly into perspective, assume that a plane taking off has reached a speed of 100 knots when it reaches the flexible pavement section and that the speed of the load cart is 5 knots. It could then be roughly estimated that shear displacements would be on the order of magnitude of 20 times greater under the load cart than under the rapidly moving plane. Or, again, roughly it would require 20 passes of the rapidly moving plane to cause the shearing displacement caused by 1 pass of the slowly moving load cart."

OCE discussion on AI comments "l" and "m"

The fact that a rapidly moving load causes less distress than a slow load application is well known and was considered in establishing the loading requirements at Columbus. The ratio of 20 to 1 proposed by the Asphalt Institute is believed to be entirely arbitrary, however, and could not apply for both the asphaltic concrete and the base course, subbase, and subgrade phase. The Corps of Engineers has considered the effect of aircraft speed on the performance of flexible pavements and the loadings and coverage levels proposed at Columbus are believed representative.

It is of interest that the Asphalt Institute maintained before the committee in June that asphaltic concrete pavements would perform adequately in channelized areas which are subject to higher loads, more coverages, and slower traffic speeds than the runway interior pavements.

n. AI comment

"There is also a need for data on average landing loads and tire pressures as well as data on the percentage of planes which take off fully loaded. With such data, we feel that a more realistic appraisal of the 5,000 coverage level could be made."

o. AI comment

"Considering the various factors discussed above, and using engineering judgment to the extent of our capabilities where factual data are lacking, it is our considered opinion that conditions established for the accelerated traffic tests are reasonable, except for the adopted landing gear load. We believe that a one-third reduction in the 265,000-pound gear load would still provide conservative conditions for the test."

OCE discussion of AI comments "n" and "o"

These points have previously been covered under paragraphs *h*, *i*, *j*, and *k* above. With regard to the Asphalt Institute's "belief" that a one-third reduction in the 265,000-pound gear load would be adequate for the test—the Corps of Engineers has no supporting data on the basis of performance of pavements over the past 15 years to reduce the test loading by more than the 20 percent assumed in current design criteria for runway interiors.

COMMENTS AND ACTION BY THE CHIEF OF ENGINEERS ON SPECIFIC RECOMMENDATIONS BY THE ASPHALT INSTITUTE IN THEIR SECOND LETTER DATED NOVEMBER 13, 1957, TO THE CHIEF OF ENGINEERS

(Recommendations of AI are designated in the same manner as in the letters presented to the subcommittee on January 9, 1958.)

AI recommendation "1. Section 5–04 (e)"

"This section would permit the use of an antistrip additive, based on a laboratory test which, in our judgment, is of little or no significance. It is our recommendation that aggregates used for this test section be those which have a satisfactorily proven record in highway performance and that an additive not be used."

OCE comment. (Recommendation will probably be effected.)

(1) The raising of a question on the possible use of an antistrip additive by the Asphalt Institute is somewhat superficial in that (*a*) if needed, it reduces the quantity of asphalt in a mix and (*b*) the Asphalt Institute blamed, in part, the failure of the asphaltic concrete in the Kelly test on the use of such an additive.

(2) The Corps of Engineers permits the use of an antistrip additive with certain aggregates which show a stripping characteristic as well as in mixes which indicate a possible emulsification under traffic. Experience at the Waterways Experiment Station has never shown any adverse performance that can be attributed to the use of an antistripping additive and has shown a major increase in pavement life through use of the additive in delaying or preventing the occurrence of emulsification. On one test section where this factor was the only variable, pavement life was increased from less than 1,000 to more than 4,000 coverages.

(3) *It is probable that the proposed aggregate will not require an antistrip additive;* however, this question should be resolved by WES and the SAD laboratories in establishing the final mix design. The Mobile District will obtain and document the performance of the proposed aggregates in asphaltic concrete pavements from local highway experience.

AI recommendation "2. Section 5–05 (a)"

"It is recommended that a 60–70 penetration grade asphalt cement be used instead of the presently specified 85–100 penetration grade."

OCE comment. (Recommendation will not be effected)

(1) It is believed that this recommendation was made for the express purpose of assuring a product which would perform most favorably under the short

duration of traffic test conditions without considering the fact that the pavements must serve for a considerable number of years in all ranges of temperature and weather conditions. It is quite possible that the use of a 60–70 penetration grade asphalt would provide a better pavement for short term hot weather traffic but it must be recognized that performance during cold weather operations could easily be penalized. The use of the reduced penetration grade would also introduce an additional question on the durability of the pavement which is already a matter of some concern due to the low asphalt content.

(2) *The recommendation for the 60–70 penetration grade apshalt cement will not be incorporated in the specifications* for the test sections at Columbus Air Force Base.

AI recommendation "3. Section 5–06"

"It is recommended that aggregate gradation limits be established on the basis of mixes judged to be most satisfactory in accelerated traffic tests by the Flexible Pavements Branch."

OCE comment. (Recommendation will be effected)

Representatives of the Flexible Pavement Branch of the Waterways Experiment Station have stated that the proposed aggregate gradations are capable of producing a satisfactory product. The only reservation on the proposed aggregate at this time concerns the fractured face count which appears to be borderline. This question will be resolved in establishing the final mix design and the Waterways Experiment Station will furnish the Chief of Engineers a letter stating the specified gradations are satisfactory.

AI recommendation "4. Section 5–07"

"Because of the critical nature of asphalt content in accelerated traffic tests, it is recommended that the tolerance on asphalt content for surface and binder course mixes be reduced to ±0.2 percent. It is further recommended that mixing temperature tolerances be ±15° F."

OCE comment. (Recommendation will be effected)

(1) Representatives of WES agree that a closer control on asphaltic concrete mixes with the reduced asphalt content (—20 percent) would be desirable. On the Columbus runway, however, this lean asphalt content applies to all flexible pavements within the center 75-foot width of runway as well as in the extensions to the intermediate taxiways. Consequently, any change to the specification for asphalt control would apply to large areas outside the 500-foot test section and possibly involve a major cost item in a change order.

(2) It was decided that the specifications would not be changed but that *an even closer tolerance than recommended by the Asphalt Institute would be effected on the lean asphalt content pavements by closer inspection.* The Waterways Experiment Station will study the possibility of specifying closer tolerances in the future by establishing the control ranges on the basis of a percentage of asphalt content. For example a ±5 percent of asphalt content tolerance would give increment limits of ±0.2 percent for mixes with 4 percent asphalt and ±0.3 percent for mixes with 6 percent asphalt.

AI recommendation "5. Section 5–09 (b)"

"Recommend addition of the following: 'The surface of the roller wheel shall be true; no surface irregularities will be permitted'."

OCE comment. (Recommendation will be effected.)

The intent of this recommendation is good. However, these factors are covered adequately by existing specifications and no change will be required.

AI recommendation "6. Section 5–13 (a)"

"This section requires premixing of all coarse aggregates as well as premixing of all fine aggregates. The Asphalt Institute does not consider this to be good practice."

"It is recommended that similar provisions be included in the project specifications. It is our understanding that such premixing is not permitted in some divisions of the Corps of Engineers and that these divisions have specifications which require separate cold-feeds for each aggregate."

OCE comment. (Recommendation will be effected.)

(1) The contractor on the Columbus job will not use premixing in that the plant he has established offers ample facilities for separate cold feeding.

(2) Corps of Engineers guide specifications are currently being revised to eliminate premixing and require sufficient plant for separate cold feeds on each asphaltic concrete aggregate.

(3) In order to eliminate any inconsistency, the project specification at Columbus will be revised by change order from the Mobile District to eliminate premixing of aggregates. It is not anticipated that this change order will effect an increase in cost in view of the plant for cold feeding already established by the Columbus contractor at his own option.

AI recommendation "7. Section 5–14"

"Requires that truck beds be oiled with a thin oil. We recommend that oil not be permitted and that the following be inserted: 'The truck beds shall be painted or sprayed with a lime-water or soap solution at least once a day or as often as required. After this operation, the truck bed shall be elevated and thoroughly drained; no excess solution shall be permitted'."

OCE comment. (Recommendation will be effected.)

The Mobile District, in a pending change order, has specified the use of lime water for truck beds on the entire job. This requirement will be effected in Corps of Engineers Guide Specifications for application to all hot mix asphaltic concrete pavement construction by the Corps of Engineers.

AI recommendation "8. Section 5–15"

"It is recommended that a minimum of two finishing machines be required and that they be operated in tandem and in such a manner as to provide for a maximum of hot joints."

OCE comment. (Recommendation will probably be effected.)

It should be noted that the elimination of all cold joints in normal airfield pavement construction is not possible. The number of finishing machines required is dependent upon plant production and where plant production is large standard Corps of Engineers practice is to place two or more finishing machines in echelon thus giving a "maximum of hot joints." Since all joints cannot be "hot" and since the United States Air Force may, by agreement, select any location within the test areas for traffic application, the recommendation will be effected only if the plant production warrants the use of two finishing machines. This is probable.

AI recommendation "8. Section 5–15" (continued)

"It is also recommended that where tack coats are to be used, an Asphalt Institute grade SS–1 emulsified asphalt be required. This emulsified asphalt should be applied at a rate of 0.05–0.10 gallons per square yard, depending upon the texture of the surface being tacked. It should be diluted with water to achieve better application uniformity, increasing the application rate of the diluted material to provide the required amount. We also recommend a diluted emulsified asphalt on contact surfaces abutting the pavement. The ratio of water to emulsified asphalt should be on the order of 1:1 to 1:2. It is preferable to spray this material rather than paint it on the surface."

OCE comment. (Recommendation will be effected.)

Diluted emulsified asphalt will be specified for tack coat, but the application rate will be 0.03 to 0.20 gallon per square yard of base asphalt rather than the 0.05 to 0.10 gallon per square yard of emulsion as recommended. This modification in rate of application is considered necessary to properly account for various degrees of dilution while at the same time permitting sufficient quantity of tack coat to prevent shoving of the asphaltic concrete during placement and rolling. Undiluted emulsified asphalt will be specified for contact surfaces and spraying will be required in lieu of painting. These actions will be effected by change order but will require modification to a pending change order already prepared by the Mobile District. The grade of emulsion will be specified by reference to the Federal Specification rather than the institute's.

AI recommendation "9. Section 5–16 (a) (1)"

"It is understood that in addition to the 98 percent minimum density requirement, a 100 percent maximum density requirement will be added."

OCE comment. (Recommendation will be effected.)

This comment was agreed to by the Corps of Engineers immediately following the Atlanta conference in October. The 100 percent maximum density is specified by the Mobile District in a pending change order.

AI recommendation "10. Section 5–17 (a)"

"See 8 above regarding the application of asphalt on contact surfaces."

OCE comment. (Recommendation will be effected.)

Undiluted emulsified asphalt will be sprayed on contact surfaces in accordance with modified change order mentioned in connection with "8. Section 5–15" above.

AI recommendation "11. Section 5–17 (c)"

"Should require that all joints be straight and true to line."

OCE comment. (Recommendation will be effected.)

A string line will be used to control joint alinement. This will be done within provisions of the existing specifications. If the contractor objects to providing this control, the project office inspectors will do it.

AI recommendation "12. a"

"That further study be given to the design of the longitudinal joint between flexible and rigid pavement with the view of providing a satisfactory, watertight joint. Certain suggestions were made on this feature at the Atlanta conference."

OCE comment. (Recommendation will be studied.)

(1) The Corps of Engineers agrees that a study of joint seal performance between rigid and flexible pavements is needed. WES representatives cannot recommend a joint seal type at this time which will assure no softening or "cutting back" of the adjacent asphaltic concrete pavement. WES will enter into such a study for the purpose of developing a sealing technique at rigid-flexible junctures in future projects. It is doubtful that this work will be accomplished in time to incorporate the results in the Columbus runway.

(2) As a matter of interest, these longitudinal joints at the juncture between the rigid keel and the flexible pavements are not in the proof-rolling section.

AI recommendation "12. b"

"If asphaltic pavement is placed this fall, it is recommended that it occasionally be rolled with a rubber-tired roller until test traffic is begun. If placed next spring, it is recommended that the pavement be allowed to cure for at least 1 week. During this period, a moderate amount of rolling with a light, rubber-tired roller would be desirable."

OCE comment. (Recommendation will not be effected.)

(1) Present estimate for placement of the asphaltic concrete pavement is May 15, 1958, as the earliest possible date. Corps of Engineers representatives agree that the 1-week curing period is reasonable and this curing time will be provided prior to application of traffic.

(2) Although the "moderate" or "occasional" rolling after placement would be desirable, it was the concensus that such practice is not practical in prototype construction. Even if the Corps of Engineers were to require after-placement rolling, there would be no assurance that the United States Air Force would continue the practice after they accept the pavement. After-placement rolling will not be accomplished on the runway at Columbus.

AI recommendation "12. c"

"It is recommended that the sequence of construction be planned in such a manner as to provide proper surface drainage at all times."

OCE comment. (Recommendation will be effected.)

This recommendation is standard practice and will be followed within the framework of existing specifications.

AI recommendation "12. d"

"It is recommended that the base be primed immediately after construction and rolled with a rubber-tired roller."

OCE comment. (Recommendation will be effected.)

This recommendation will be incorporated in a change order by the Mobile District for application in the proof-rolling sections only. Corps of Engineers guide specifications will be revised to require rubber-tired rolling on the completed base course immediately after priming on all flexible airfield pavements.

Mr. HÉBERT. Now, on an overall résumé of the criticism made by the portland cement industry?

General BROWN. Yes.

Mr. HÉBERT. Did you object to all their criticisms or do you agree with any of them?

General BROWN. We have those in detail. I don't believe I could actually generalize on our comments, Mr. Chairman, but I have them here.

Mr. HÉBERT. Well, did you agree with them in any area? Not specifically. I just want to get the overall picture.

Mr. HARDY. If he will put those in the record, Mr. Chairman, we can analyze them later.

Mr. HÉBERT. Will you do that, General?

General BROWN. All right, sir.

Mr. HÉBERT. Mr. Cunningham?

Mr. CUNNINGHAM. No questions.

Mr. HÉBERT. Mr. Osmers?

Mr. OSMERS. No questions.

Mr. HÉBERT. Mr. Courtney.

Mr. COURTNEY. Mr. Chairman, I would like to ask the general a question with reference to the prospective cost of this particular test. Do you have an opinion and can you advise the committee as to what the probable cost of the specific test being made on flexible pavement is?

General BROWN. If I might—Mr. Foster, who appeared before the committee earlier, is here. If the chairman permits, I would like Mr. Foster to address himself to that and other questions you may have on that.

Mr. HÉBERT. Mr. Foster, will you please step forward?

Mr. HARDY. Mr. Chairman—before Mr. Foster starts—inasmuch as we have asked the general to submit his comments with respect to the points raised by the Portland Cement Association, I wonder if we shouldn't have also his detail of his reactions to the asphalt recommendations so we can see the basis on which he agreed to 14.

General BROWN. Yes, sir.

Mr. HÉBERT. And what the two were that he didn't agree to, and why.

General BROWN. Yes, sir; we can do that.

Mr. HÉBERT. Now, Mr. Foster.

Mr. COURTNEY. Go ahead, Mr. Foster. You are in the record.

Mr. FOSTER. The question as I got it, is what is the estimated cost of the specific test at Columbus?

Mr. COURTNEY. That would be in two parts, one the construction cost and the other, the actual testing, if you have it.

Mr. FOSTER. I can't answer on the construction costs. I have no responsibility on that. I don't know what the cost of constructing the specific test sections are, but they are not much more than constructing the same amount of pavement that would normally be required.

The cost of operating the traffic test, which is the part that I am involved in, has been estimated—we estimated $127,000. The majority, or at least the large amount of that is contingencies, because we do not know how many hours a day we can operate. There are $40,000 worth of contingencies there, roughly.

Mr. COURTNEY. In that grouping?

Mr. FOSTER. Yes.

Mr. COURTNEY. Are you satisfied in your judgment representing the laboratories and the technical end of it that the kind of test that has been devised is adequate for the purpose?

Mr. FOSTER. Yes, sir.

Mr. COURTNEY. General, referring, then, to this test pavement so the record may be clear. Then the record is clear that this is an airfield which was to be constructed for operational use of B–52's and the section which is under test is merely a part of that field?

General BROWN. That is correct; yes, sir.

Mr. COURTNEY. And the design plan which is shown on the chart, the last of the plans is a designed plan with the extension of the runways to conform to the present requirements of B–52–G's?

General BROWN. That is right, sir.

Mr. COURTNEY. General, on one side, so we may be clear, on the lower portion of the chart, you have a cross section of a runway—on the proposed test section, indicating a depth of approximately 62 inches which is to be considered a part of the pavement construction, is that right?

General BROWN. We consider the flexible pavement as being from the subgrade up. The pavement then would consist of 4 inches of asphalt concrete, 11 inches of crushed gravel, and 23 inches of sand and gravel and clay-gravel, on a compacted subgrade.

Mr. COURTNEY. Now the compacted subgrade——

General BROWN. This is not considered as part of the pavement.

Mr. COURTNEY. But it is, nevertheless, a compacted subgrade. And that is how much inches now?

General BROWN. Well, it will vary depending on exactly what exists—we show here a 60-inch compaction——

Mr. COURTNEY. That depends on natural soil conditions.

General BROWN. What exists, sir, or what we put in as fill.

Mr. COURTNEY. Right. Now, General, will you explain the same hatchmark in the yellow markings to the right of that chart?

General BROWN. This detail is indicated here only to show how we join the proof test section with the yellow traffic lanes.

Mr. COURTNEY. Then to recur, General, if I may, just so the record may be clear on it. The 2,500 feet that you show in yellow, the 75-foot, 2,500-foot runways——

General BROWN. The traffic lanes.

Mr. COURTNEY. The traffic lanes, within the hatched black area, are intended only to meet the particular conditions that were found at this field and as a matter of economy rather than a matter of fixed continuing design.

General BROWN. That is correct. It is a construction expediency that was agreed upon and decided upon because of, as I indicated, further certain conditions that we found in the material that had been placed as not meeting the design standard.

Mr. COURTNEY. So that is for this field?

General BROWN. That is correct, yes, sir.

Mr. COURTNEY. And establishes no pattern as to what might or might not be done on any other construction?

General BROWN. That is how we consider it, yes, sir.

Mr. COURTNEY. Mr. Ferry, I think we have a question of him, Mr. Chairman. Mr. John Ferry.

Thank you, Mr. Foster.

Mr. Ferry is already in the record. This is a continuation of the previous record.

Mr. Ferry, with reference to the construction program as to which this new design and this test may be applicable in the future, the purpose being to ascertain whether the two materials may be made competitive or alternate, is any money now committed or any contracts planned or projected before this test will have been completed which would be upon an exclusive portland cement basis?

Mr. FERRY. Yes, sir.

Mr. COURTNEY. What?

Mr. FERRY. We have present contracts now in being and work in progress on exclusive concrete construction.

Mr. COURTNEY. Now when you speak of exclusive concrete construction, are you referring to what has been described as critical areas or are you referring to entire runways?

Mr. FERRY. To the entire runway, Mr. Courtney.

Mr. COURTNEY. And out of what appropriated moneys are those contracts to be funded?

Mr. FERRY. Those are funded out of funds provided in fiscal 1956, 1957 and 1958.

Mr. COURTNEY. And 1958?

Mr. FERRY. Right, sir.

Mr. COURTNEY. But there have been no commitments out of fiscal 1959 of which you are aware, or plans?

Mr. FERRY. No, sir.

Mr. COURTNEY. General, one question I neglected to ask, unfortunately, is when is it expected that your test will be completed, so that the criteria may be considered and agreed upon?

General BROWN. That is a question I can't specifically answer.

Mr. COURTNEY. Well, in general terms.

General BROWN. It will depend a great deal on the temperatures that exist. As Mr. Foster implied, his contingency addition of $40,000 will depend on whether he can operate his test rolling through a full 24-hour period or whether it gets so warm and his number of passes at a certain temperature—he can't stress the pavement any more at a particular temperature than the average temperature curve throughout an annual period permits.

Mr. COURTNEY. Well, do you have any opinion within any reasonable bracket?

General BROWN. Could I again ask Mr. Foster to give a guess at that?

Mr. COURTNEY. What is your opinion, Mr. Foster?

Mr. FOSTER. Our estimate starting the 15th of April was 1 month. If we start 15th of May, I am sure it would be 2 months and maybe 2½ months.

Mr. COURTNEY. And, thereafter, of course, will come the evaluation of the data which you have accumulated, is that right?

Mr. FOSTER. That is right. Of course, we hope there will be no evaluation necessary.

Mr. COURTNEY. Thank you, Mr. Foster, general, do you have anything further?

General BROWN. I have nothing further.

Mr. COURTNEY. Mr. Ferry.

Mr. FERRY. I would merely like, and note only for the record, to state that the Air Force position is completely in agreement with the Corps of Engineers design that has been shown to the committee today.

We consider it to be represenative, and as true to actual conditions of a B–52 field, as we can possibly make it.

Mr. COURTNEY. Mr. Chairman, I think that is all for the record at this time.

Mr. HÉBERT. There is one point I want to requestion and get it clear certainly in my mind, and that is about the varying types of your subsoil in the various sections of the country or various fields. I recognize that the Mississippi subsoil there is probably different from Texas or Nebraska or other sections of the country.

Now, would that cost of construction of the subsoil, after you build to your solid surface—would that be the same if concrete was to be put on the area of asphalt?

Would that be a factor?

In other words, would you have to change your foundation construction if you used asphalt as against concrete or concrete as against asphalt?

Mr. FERRY. Yes, we would, sir.

It would, of course—I would prefer the general would answer that question. I think I was thinking out loud. If the general will answer it, I will concur with him.

General BROWN. I would feel, Mr. Chairman, that no two designs ever agree when you compare one airfield with another.

I would guess the relationship in costs that may exist at one airfield —that relationship percentagewise or proportionately expressed may be pretty close at another one.

Mr. HÉBERT. Then you would say that that would not be a factor in cost?

General BROWN. The existence of various types of soil will be a factor, yes, sir.

Mr. HÉBERT. In favor of the asphalt construction or in favor of the concrete construction? In other words, General, we are not engineers on this committee. We face a very difficult problem. We are not trying to make the decision. We are just trying to learn from a layman's approach to the problem.

In other words, you have a soil which varies in different sections of the country or the world.

Now, does it take a more expensive foundation to carry the heavier weight of concrete than to carry the lighter weight of asphalt, and I am assuming that asphalt is of a lighter weight than concrete?

General BROWN. I am not sure whether I understand your question or not, Mr. Chairman. But if you compare the costs of the two pavements, I feel in all fairness you must from here up [indicating] call that the cost of the flexible pavement and the 6, 4, or 8 inches of material under the portland cement, plus the cost of the portland cement.

Mr. HÉBERT. What would that make it a higher cost?

General BROWN. It probably would, yes, sir.

Mr. HÉBERT. Yes. For concrete as compared to asphalt?

General BROWN. It probably would.

Mr. HÉBERT. So you need a more expensive foundation for concrete.

General BROWN. Oh, no, sir; no, sir.

Mr. FERRY. No.

General BROWN. You will recall—maybe if we refer back to this chart we might have a meeting of the minds on your question, Mr. Chairman.

Mr. HÉBERT. General, I would like to ask Mr. Courtney to state the question as I would have liked to have it stated it?

Mr. COURTNEY. Well, the purpose of this inquiry generally is to consider costs so far as they may be represented in alternate material uses. Of course, those would vary with soil conditions—subsoil conditions, use, weights, and all the other factors.

I think what the chairman has in mind is whether there is any balance in favor of concrete on given soil conditions versus flexible pavement.

Mr. SALE. May I answer that, please?

General BROWN. Yes.

Mr. COURTNEY. Mr. Sale, explain the problem.

Essentially, the question of the committee has to do with overall cost and comparative costs and competitive materials.

Mr. SALE. Sir, we start off and admit that in various parts of the country the cost of paving materials also vary.

Mr. COURTNEY. Yes.

Mr. SALE. But speaking in general from this point, if the existing foundation as Mr. Hébert said is good—and we will find these in various parts of the country such as Florida and places in New England——

Mr. HÉBERT. Yes.

Mr. SALE. If we have an existing high-type foundation upon which to build, this is most favorable to an asphaltic concrete.

The pavement thicknesses are relatively thin on good foundations; whereas, the amount of thinness we can introduced into a concrete pavement is relatively small as compared with what is required elsewhere.

Anyplace where we have clay foundations existing and very few high-type foundations, is much more favorable toward concrete construction. We require a little more thickness than on a good foundation.

But on an asphaltic concrete we require tremendous increases in thickness.

And in order to build a flexible pavement on a poor foundation, you must build up and bring in good materials for the subbase and base course.

All we have to do on rigid pavement is to increase the thickness a matter, for these loadings, of maybe 6 or 7 inches.

Mr. HÉBERT. Now, in all these discussions about both the cement and the asphalt, there is one thing I want to make clear, as far as I am concerned, and I would ask Mr. Cunningham to elaborate later on it, and that is that we are to assume that both are equally safe for the individual; is that correct?

Mr. COURTNEY. When you agree on the design?

Mr. HÉBERT. When you agree.

Mr. SALE. Yes, sir.

Mr. HÉBERT. Mr. Cunningham raised that point before and I would like an expression from him.

In other words, we are not putting the life of the individual below the cost of construction. If the safety element present in either the concrete or the asphalt favors one or the other, then price is of no concern, that is the cost is of no concern. I am assuming that we are proceeding from the basic assumption or basic consideration of safety first to the pilot, to the individual.

Mr. FERRY. Perhaps that should be addressed to the Air Force, Mr. Chairman, rather than the Corps of Engineers, from the operating angle.

Mr. HÉBERT. Whoever wants to talk.

Mr. FERRY. I would answer that, I think, by saying that as far as our records are concerned, we are unable to determine any difference in fact or of increased hazard with either paving.

Mr. HÉBERT. That is what I wanted to make sure, that we understood that we are not sacrificing the safety factor in favor of the cost factor.

Mr. FERRY. That is quite correct.

Mr. CUNNINGHAM. I think that is my position exactly, Mr. Chairman. I would vote to pave them with steel if that would assure more safety and eliminate the loss of lives to our soldiers—our servicemen.

I am not concerned as to whether it is one kind of pavement or the other. I want the best. And I think our servicemen are entitled to it. I think that is the primary purpose of this hearing, is it not?

But we are not engineers.

Mr. FERRY. Mr. Cunningham, from the human safety angle, either portland cement or an asphaltic surface on our runway, properly built, will equally well serve the purpose.

Mr. CUNNINGHAM. That answers the question.

Mr. FERRY. Yes, of both design and construction. From a wear standpoint, however, a use standpoint, from a long-term use standpoint, I would like to reiterate that this test is to establish whether or not asphaltic pavement over a period of years can withstand the heavy traffic loads imposed——

Mr. CUNNINGHAM. Now, you are getting back to the safety factor that bothers me.

Mr. FERRY. No, sir. I am talking about whether or not it will continue to function over a period of years.

Mr. CUNNINGHAM. That is just exactly it. At what period of time will that deteriorate so that one of them is less safe than the other?

Mr. FERRY. At no time.

Mr. CUNNINGHAM. At no time.

Mr. FERRY. As soon as a paving deteriorates to the point that it needs repairs, we go in and make repairs.

Mr. HÉBERT. That establishes the proposition, I think. We are in agreement that both are equally safe.

Mr. FERRY. That is correct.

Mr. HÉBERT. So having agreed that both are equally safe, then we take into consideration the cost factor.

Mr. FERRY. Cost and life.

Mr. HÉBERT. We have agreed now that they are both equally safe as far as life is concerned.

Mr. CUNNINGHAM. Cost and life?

Mr. FERRY. The term of utilization.

Mr. HÉBERT. That is correct.

So then our determination is to find the most economical product of the two. Competitively, I mean.

Mr. Courtney, anything further?

Mr. COURTNEY. Mr. Chairman, I think that is all, with the addition of the material which the general will be kind enough to furnish for the record.

Mr. HÉBERT. Mr. Fisher has a question.

Mr. FISHER. Just one question.

I am a little confused in talking about foundation in various areas, and under various conditions upon which you place the concrete or the asphalt.

Would you say that generally speaking you require substantially the same foundation upon which to put the concrete that you do to put asphalt?

General BROWN. If you have a particular foundation to which you want to place one type of pavement or the other.

Mr. FISHER. Yes.

General BROWN. You start with the same base and you can design a flexible pavement to fit on that foundation or a rigid pavement to fit on that foundation.

Mr. FISHER. I gathered from what you said a moment ago that under certain conditions, depending on the type of foundation, you would increase the thickness or decrease the thickness of the concrete.

General BROWN. It is part of the element of design, yes, sir.

Mr. FISHER. Of course, if you had to increase it, that would increase the cost.

General BROWN. That is right.

Mr. FISHER. To that extent.

Mr. COURTNEY. Then, Mr. Chairman, in addition we have handed or will hand the general a letter which has been received from the National Bituminous Pavement Association, for comment, which Mr. Chairman, I would like to ask the general to give those for the record.

Mr. Chairman, when that material has been furnished, I would recommend that the committee authorize the publication of the content of this proceeding, and that the hearing then be recessed until the event of the test.

Mr. HÉBERT. I have one question to ask the general.

General, because of the wide divergence of opinion between the two industries and your conclusions—I understood you to say that certain evaluations or certain data was classified and not available to either one of the two. Is it possible that that wide area could be closed in if the data has been available to either or both of the industries?

General BROWN. It may have.

Mr. HÉBERT. It could have a bearing on the conclusion.

General BROWN. It may have, especially on the part of Mr. Wellborn of the Asphalt Institute, and his people.

Mr. HÉBERT. Of course, I mean that is a classified matter. We don't ask you to discuss it. I just want an opinion because you are sitting in judgment on it, and have available certain data which can't be released to either of the two.

General BROWN. Well, if we consider the loading that we are imposing on the test sections, we reduce from the maximum 20 percent.

Mr. Wellborn recommended a 33⅓ percent reduction. That is far apart, but as you point out, perhaps, if all the data that we have available to us were made available to Mr. Wellborn, that spread might well have been shortened. We might have come a little closer, yes, sir.

Mr. HÉBERT. And you consider the classification of that material fully justified?

General BROWN. It is an Air Force classification because the disclosure of it will disclose, as I understand it, certain operating techniques of the B–52 aircraft.

Mr. HÉBERT. I see.

Thank you very much, General.

The committee will stand in recess and the testimony and data may be disseminated as soon as printed.

Mr. HÉBERT. Thank you very much, General.

General BROWN. Thank you.

(At 11 : 15 a. m., the subcommittee recessed.)

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